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ABSTRACT

This document contains the full and short papers on interactive learning environments from ICCE/ICCAI 2000 (International Conference on Computers in Education/International Conference on Computer-Assisted Instruction) covering the following topics: a CAL system for appreciation of 3D shapes by surface development; a constructivist virtual physics laboratory; a distributed backbone system for community-based collaborative virtual universities; a Java-based interactive learning system for junior high school level geometry; a learning environment for problem posing in simple arithmetical word problems; the effectiveness of a World Wide Web-based collaborative learning system on school mathematics; a Web-based interactive exercise system for learning mathematical functions; situated learning and college students; an environment for learning by design; implementation of a campus distance learning system using Multicast; an interactive game system to stimulate word associations; an online intelligent tutoring system for elementary algebra; application of the gray relationship matrix and learning obstacles analysis to discovery teaching; construction of an in-service training Web site for school teachers; construction of a real-time CAD learning system in a Web-based environment; extensible simulation-oriented collaborative virtual learning environments; an effective Web-based learning environment for overseas Chinese education; an information technology-immersion environment to enhance learning and teaching in design and technology; a cross-cultural communication system and Web-based Japanese education; a Web-based multi-server testing system; a log-file analysis program for assessing navigation processes; interactive explanations using both images and texts for Micro World; a Web-based interactive learning environment; electronic mail systems in computer literacy instruction; the Internet video-on-demand system of classroom teaching; learner control in technology-mediated learning within a constructivist model; algorithm design through interactive simulation; digital logic design by concept mapping; computer-mediated communication in remote off-campus cross-cultural contexts; MathCAL's diagnostic sub-system; meta-knowledge agent; the network usage survey related to university students

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and occupational groups in Taiwan; a networked constructive CAI system; real-time handwriting communication systems for distance education and collaborative learning; engineering professional practice using an interactive Web-based resource; students' thinking processes when learning with computer-assisted mass lectures; the application of scaffolding theory on the elemental school acid-basic chemistry Web; dynamic knowledge generation and the learning potential ability; the externalization support system of self-explanation for learning problem-solving process; the impact of learning style on group cooperative learning; the usability aspects of a universal brokerage and delivery system for the Pan-European higher education; virtual inhabited 3D worlds and Internet-based learning environments; a language learning system on the Web; and Web-supported environments for learning and teaching statistics. (MES)

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A CAL System for Appreciation of 3D Shapes by Surface Development (C3D-SD)

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A web-based Computer-aided learning system for 3D - Surface Development Module (C3D-SD) has been developed for teaching the appreciation of 3D geometric shapes by unfolding the surface boundary of a solid object into a planar 2D pattern. The problem is similar to the problem of surface development in technical drawing and highly related to the reverse problem of folding a 2D shape into a 3D object, with practical applications in sheet metal work, pattern making, and packaging design. C3D-SD makes extensive use of animation, interactive control by the student, and quizzes to present the material and to engage the students. It makes use of the solid modeling library SML to create 3D solid shapes by Boolean combinations (union, intersection and difference) of primitive shapes, and Java3D for rendering and animation. It includes a Packaging Design Module which builds on the Surface Development module by automatically adding flippers and minimizing the rectangle enclosing the unfolded pattern. This system is the second installment of a series of CAL systems for Three-dimensional Geometry that the authors have been developing.

Keywords: **3D geometry, surface development, animation**

1 Introduction

Surface development is an important technique in design. Generally it involves unrolling a curved surface into a planar 2D pattern. Theoretically speaking only certain classes of surfaces are "developable" [Carmo 1976]. If, however (as is the case in many computer graphics systems), curved surfaces are approximated by sets of planar facets, then all curved surfaces can be unfolded into 2D planar shapes, although they may appear to be "unnatural" or "ugly". A related problem is the unfolding of the planar faces bounding a facetted solid object into a planar 2D shape. The inverse of the problem is folding a planar 2D shape into a 3D object, e.g., folded the card-board boxes for hamburgers in fast-food restaurants. These techniques have practical applications in sheet metal work, pattern making, packaging and package design, etc. [Giesecke et al 1997] This paper describes the development of a Web-based computer-aided learning system for teaching the appreciation of surface development/unfolding based on a polygonal representation of solid objects. It is a part of a series of Web-based tools for teaching 3D geometry that our group has been developing. A previous project focussed on sectioning and interactions between some primitive solid shapes was reported in [Chan et al 1999].

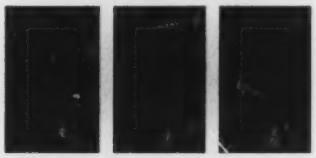
Traditional teaching materials on these topics were mainly text based. Better materials have graphics or charts in addition to plain texts. In presenting descriptive topics, this approach is adequate. However, in teaching three-dimension geometry, the two-dimensional and static presentation style is obviously not enough. The use of videos can be effective to some extend but it is still one-way communication and not interactive. A more effective alternative is to use real solid objects to help students visualize 3D shapes. But some objects are difficult to be made, and it is impossible for teachers and students to change the size, scale, shape or appearance of the object quickly.

In contrast to the limitation of 2D materials, videos and real 3D objects, a virtual environment can be a better approach in presenting certain 3D geometry problems. A virtual environment is a computer-generated environment in which 3D or even the forth dimension (time) can be presented through animation. Within the virtual environment, one can change the size, scale, shape or appearance of the virtual object interactively. To have a clearer look, one can zoom into the object. To see the inner structure, one can set part of the object

to be transparent. And geometry can be animated by transforming the object over time. And of course, an interactive teaching approach is much better than one way communication in enhancing student understanding. Finally, for purposes of accessibility and distribution, the Web is the ideal environment. These considerations drove the development of this project.

2 Overview of C3D-SD

The main problem tackled by C3D-SD is surface development, as illustrated below in Figure 1. In (a) is shown a solid cone shaped object with the top cut off at an oblique angle. In (b) the surface of the cone is in the middle of being unfolded. In (c) the unfolding is complete. Note that we had tried to keep the unfolded 2D shape connected. As a result, the curved conical surface itself became disconnected (actually connected through a single vertex). It is not difficult to see that it is possible to unfold the surface while keeping the curved conical surface connected.



(a) (b) (c)

Figure 1. Surface development in action.

C3D-SD is organized into three types of activities:

1. Tutorials - Students are guided through demonstrations, including: matching 3D solids to unfolded shapes, animations of unfolding (e.g., of the conical object in Figure 1), animations of folding 2D patterns into 3D solids, adding flippers to unfolded 2D patterns for fastening, reducing the size of the rectangle bounding the unfolded pattern, etc.
2. Free-form exercises - Students are allowed to explore the teaching material on their own. They are provided with numerous opportunities to interact with the teaching material, e.g., creating complex 3D solids by combining primitive shapes, selecting view points, putting different textures on objects, controlling the animation process, etc. The problems are similar to those presented in tutorials. But many more shapes are available for students to experiment with, for self-guided exploration and exercise.
3. Tests - Students can test their understanding of the material through multiple-choice tests. They are asked, e.g., to match an unfolded 2D shape with the solid object, such as illustrated below in Figure 2. If so desired, they can turn to the free-form exercises to explore the test shapes that they have problems with.

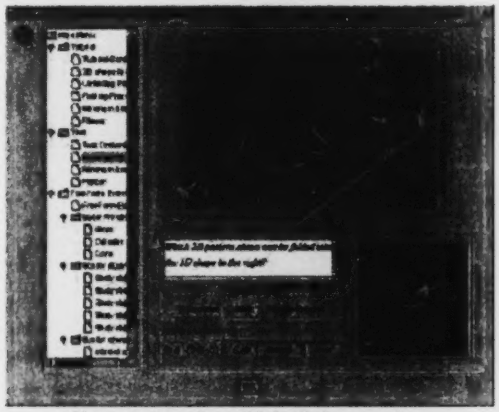


Figure 2. Sample multiple choice question.

The three types of activities are chosen for the following reasons. The tutorials provide core contents to be imparted to the students. The free form exercises allow the students to explore the subject on their own.

Different students with different backgrounds and learning styles benefit from different learning activities, hence both guided and sef-guided types of activities are provided. Finally, tests are developed to gauge the students' grasp of the material. It is expected that C3D-SD can be integrated with an intelligent tutoring system to provide a learning experience more tailored-made for the individual students.
C3D-SD focuses on five types of problems:

1. Matching 3D solid shapes with the corresponding unfolded 2D patterns.
2. Unfolding the surface boundary of a facetted solid and developing curved surfaces.
3. Folding 2D patterns into 3D solid shapes.
4. Simple packaging design: Adding flippers to the unfolded 2D pattern for fastening.
5. Simple packaging design: minimizing the rectangle bounding the unfolded 2D pattern.

3 The 3D Solid Design Module

Java was chosen to develop this system as it is a web-oriented development language and only a Java-enabled Web browser (e.g. Netscape, Microsoft Internet Explorer) is needed to access the Web pages without installing other plug-ins. However, it is difficult to build 3D applications using only the core Java classes. A Java-based high-level programming library, Solid Modeling Library (SML) [Chan et al 1998] is used in C3D-SD for designing 3D solid objects. SML supports the building of 3D solid objects through a set of atomic functions called Euler operators. These functions allow the incremental manipulation of Boundary Representation (B-rep) models, while processing the underlying well-formed data structure. It also supports the creation of solid primitives (block, cylinder, cone, sphere, torus) and Boolean operations (union, intersection, and difference) on solids and transformations (translation, rotation) of solid objects for easy creation of complex 3D solid shapes. For example, a hollow pipe can be created by the differencing (subtracting) a smaller cylinder from a larger cylinder. SML uses a hierarchical half-edge data structure that stores rich information about a solid model [Mantyla 1988], including solid-to-face, face-to-face, face-to-edge, edge-to-edge, edge-to-vertex, and vertex-to-vertex information. The data structure used in SML to represent the surface boundary of solid objects is illustrated in Figure 3.

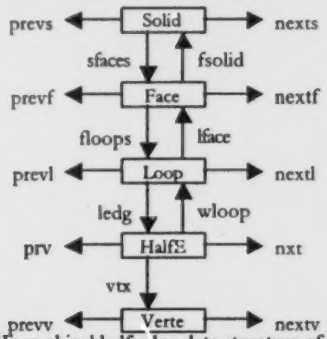


Figure 3. Hierarchical half-edge data structure of SML.

4 Surface Development

The process of surface development or unfolding is illustrated in Figure 4 using a cube as an example. Each face of the cube is coloured differently for easy identification. One might imagine that the unfolding starts by holding the bottom (red) face of the cube fixed to the horizontal plane, and rotating the rest of the cube about the edge linking the red face with the green face until the green face is in the same plane as the red face. This is followed by the blue face, then the yellow, then the light blue, ..., and finally the purple, until all faces lie in the horizontal plane.

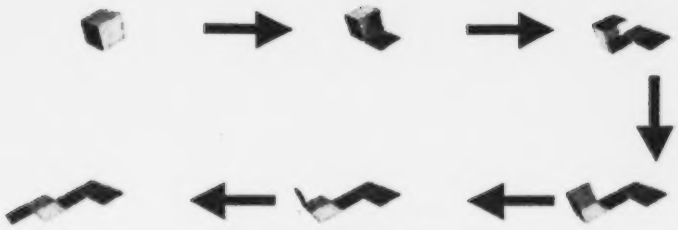


Figure 4. Unfolding a cube.

Sun Microsystems provides the Java3D application programming interface (API) which can be used to develop three-dimensional graphics applications and applets. It gives developers high-level constructs for creating and manipulating polygon-based 3D geometry and for constructing the structures used in rendering that geometry [Sowizral et al 1998, Sun 2000, Brown & Peterson 1999]. It is an object-oriented API, which can be used to construct individual graphics elements as separate objects and connect them together into a tree-like structure called the scene graph. It contains a complete description of the entire scene including the geometric data, attribute information and viewing information needed to render the scene from a particular point of view. Java3D provides a simple and flexible mechanism for representing and rendering scenes with lighting effect but it does not provide high-level construct for creating complicated solid object models. Hence SML was used to create the 3D solids which are subsequently converted into Java3D for rendering and animation.

4.1 Conversion from Solid (in SML) to Surface (in Java3D)

Each face object in SML is converted into a Java3D geometry object by using the information on the vertices of the face. As a result a SML solid object is converted into a group of Java3D geometry objects, each representing a face as illustrated in Figure 5. However, the data structures used to represent objects in Java3D and SML are different, and a conversion process is required to integrate the two systems to take advantage of their respective strengths to produce a more complete solution.

The displayable object in Java 3D is implemented by the Shape3D class. The Geometry and Appearance objects make up a Shape3D object. The Appearance objects controls the outlook of an object, e.g. color, material, etc. The Geometry object contains the vertexes information. We choose triangle as the basic shape in forming a geometry object because it contains the minimum number of vertexes that can form a plane. So that any face shape can be formed by the combination of triangles.

The conversion of an object represented in SML to one represented in Java3D involves 4 steps. Recall that each face in a SML Solid is converted into a Geometry object in Java3D.

1. Find the number of faces in the SML Solid object.
2. For each face, find the number of vertexes and the coordinates of each vertex.
3. Group three vertexes into a triangular strip.
4. Combine all triangular strips to form a Geometry object in Java3D.
5. Each Geometry object will result in a Shape3D object.
6. Group all Shape3D objects to form the representation of the solid in Java3D.

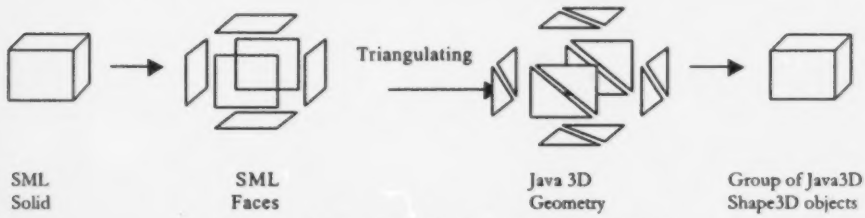


Figure 5. Converting an object from SML into Java3D.

4.2 Unfolding Path

In order to "develop" a surface approximated by a set of polygons, or to unfold the boundary of a solid, one needs to determine a connected path traversing all the faces one at a time. The path for unfolding can be

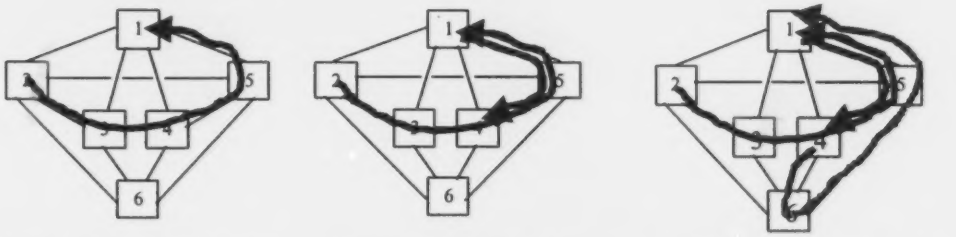
1. specified manually by the student,
2. pre-set in CAL-SD manually by the teacher, or
3. determined automatically by CAD-SD.

Automatic determination of the path for unfolding involves two steps:

- Determine the connectivity between the faces, e.g., in the form of a **graph** whose nodes are the faces, and an edge links a pair of neighbouring faces, and
- Traverse the graph to find the desired connected **path**(s) that visits each face one at a time and each face only once.

As the data structure of SML stores rich information of the complete solid, the connectivity relationships between faces can be easily derived. To derive the path(s) of traversing all faces one and only one at a time is a version of the traveling salesperson problem [Johnsonbaugh 1996]. It is a problem that is known to be hard (computationally expensive) for arbitrary graphs. In our system prototype, we chose to use exhaustive search because of its simple implementation. In future versions we may try to find a more efficient algorithm. In the default version of the algorithm, we simply try to find a solution (any solution) using the well-known **backtrack** algorithm. Firstly, pick up a face arbitrarily. Then, traverse to one of its neighbors. Repeat this process until all the faces have been visited. When a dead-end occurs, it will back track one or more steps to find another possible way (Figure 6). Dead-end means arriving at a face with no un-visited neighbours, while there are still un-visited faces remaining in the graph.

The algorithms implemented in C3D-SD so far traverse the faces of an object in a linear sequence, i.e., the unfolded faces form a linear chain of planar polygons. There are other alternatives, e.g., unfolding in two directions at the same time, resulting a Y shaped chain of polygons, etc. In future versions of the system, we will implement other unfolding algorithms.



(a) Dead-end occurs when traversing 2 ⇨ 3 ⇨ 4 ⇨ 5 ⇨ 1

(b) Backtracking from dead-end to face 4 to find another possible path

(c) Path 2 ⇨ 3 ⇨ 4 ⇨ 6 ⇨ 5 ⇨ 1 is one of the possible paths traversing all the faces one and only one time

Figure 6. Finding a possible path for unfolding the faces of a solid.

4.3 Heuristics for Developing Smooth Surfaces

In SML and in Java3D, as in many computer graphics systems, a curved surface (e.g. conical, cylindrical, etc.) is approximated by a set of planar polygons. If we choose a face's neighbor in an arbitrary way, a solid may be unfolded into an "ugly" or "unnatural" shape because the set of polygons used to approximate a smooth surface my or may not be unfolded (smoothly) in an appropriate sequence. The left side of Figure 7 shows a cylinder approximated by a total of 22 plane faces (20 for the curved surface and 2 for the top and bottom faces). If we unfold the cylinder arbitrarily, for example, following the path 1-2-3- ..-21-22, may result in the patter in the middle. One of the polygons in the set used to approximate the curved cylindrical surface is disconnected from the other polygons in the set.

We observe, however, that in the set of polygons approximating a smooth curved surface, each polygon shares at least one edge with another polygon in the set, and the included angle between the two polygons is very close to, but just slightly less than, 180 degrees. Taking account of the Smooth Surface Heuristics discussed above, we can try to select the neighbor making the largest angle with the current face, instead of selecting an arbitrary one. Applying this heuristic to the unfolding of the cylindrical solid will result in the developed surface to the right.

Figure 7. Arbitrarily unfolding the cylinder to the left may result in the pattern in the middle, and applying smooth surface heuristics will result in the pattern to the right.

5 Partially Automated Packaging Design

The design of packaging such as the rectangular boxes used to hold hamburgers at fast food restaurants involves the design of the 2D patterns that can be folded into such boxes. Similar problems exist in sheet metal work and other areas. The surface development/unfolding algorithm discussed above can be used to partially automate such designs.

5.1 Addition of "Flippers"

In addition, one also need to add "flippers" to some of the faces. Flippers are extended faces for putting glue or stickers in order to fasten two faces together when folding the planar 2D shape into a 3D solid shape. We have developed a simple algorithm to determine which edges of the faces of a solid model need to have flippers added. As flippers are used in connecting neighbouring faces, basically, all edges around a face need flippers except:

1. Edges that have been used as axes of rotation during the process of unfolding, i.e., edges between consecutive faces in the connected path for unfolding (in Figure 8)
2. Edges for which flippers have already created on the opposite face (in Figure 8)

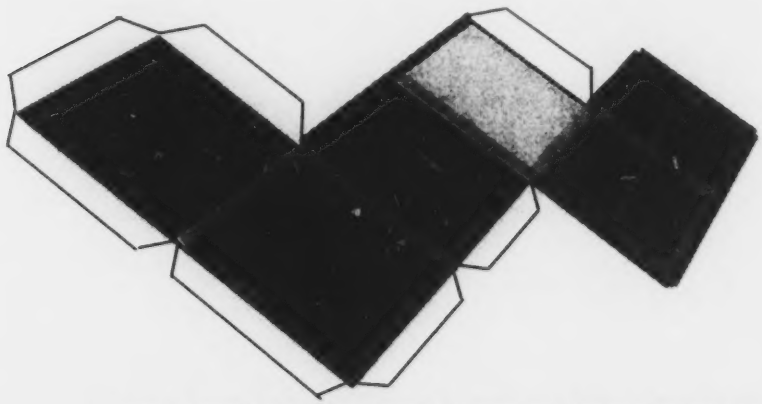


Figure 8. Creation of "flippers" in partially-automated design of packaging.

5.2 Minimizing Bounding Rectangle

The unfolding of 3D shapes are often constrained by certain requirements. For example, in the design of

packaging or sheet metal work, the unfolded shape may be the pattern to be cut out of a rectangular sheet, to be folded into the solid shape. In such cases it is desirable to reduce the amount of wastage by making the rectangular sheet required as small as possible. This translates into a requirement to minimize the area of the smallest rectangle enclosing the unfolded planar shape, as illustrated in Figure 9. Smallest rectangle enclosing the unfolded 2D shape. Such constraints may not be easy to satisfy absolutely. However, it is often enough to find a reasonable but not necessarily the perfect solution. In the case of determining a minimum bounding rectangle, it may be sufficient to find a local but not the absolute minimum. A local minimum can be determined by backtracking a few steps from the solution found to determine the set of related solutions and choose the one with the smallest bounding rectangle.

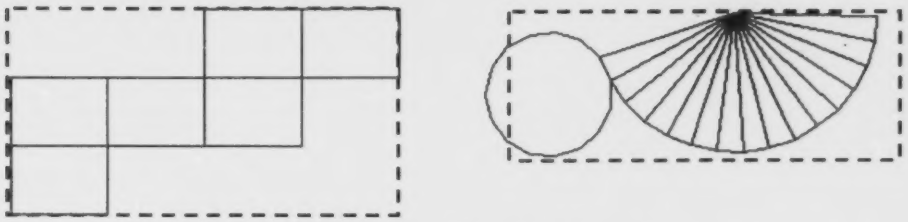


Figure 9. Smallest rectangle enclosing the unfolded 2D shape.

5.3 Some Examples Used in CAD-SD

Many examples of realistic solid shapes have been built into CAD-SD for illustrating and teaching surface development. Figure 10, Figure 11, and Figure 12 show the results of unfolding some common solid shapes, with "flippers" added automatically. For simple solid shapes it is fairly easy to deduce from the unfolded 2D patterns what the original 3D solid shapes are. Some of these are given to the students as exercises.

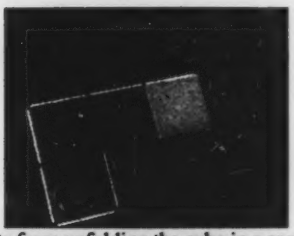


Figure 10. The 2D shape that results from unfolding the cube in a sequence different from that shown in Figure 8. Creation of "flippers" in partially-automated design of packaging., also with flippers added.

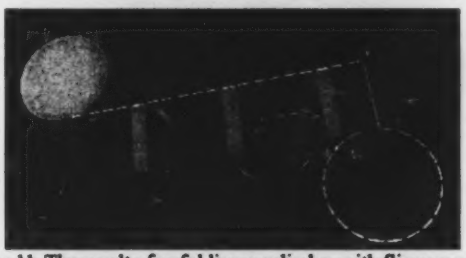


Figure 11. The result of unfolding a cylinder, with flippers added.

Figure 12. **The result of unfolding a T-shaped box, with "flippers" added.**

6 Conslusion

Using the SML solid modeling system and Java3D surface modeling and rendering system, we have successfully developed the basic structures of a CAL system that makes use of 3D modeling, animation, and interactivity to teach the appreciation of certain class of 3D shapes through surface development and unfolding. We have also shown how the unfolding algorithm can be used to partially automate the design of the 2D patterns used in certain sheet metal work and packaging design problems, by also automating the addition of flippers for attaching neighbouring faces, and reducing the rectangular sheet from which the planar (unfolded) patterns are to be cut out. Based on these basic functions, a comprehensive set of teaching materials can be developed to greatly enhance the degree and interactivity and effectiveness in the teaching of the appreciation of 3D geometry.

Acknowledgement

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A Constructivist Virtual Physics Laboratory

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A virtual Physics Laboratory with 60+ physics java applets was established for student to play and enjoy learning physics (http://www.phy.ntnu.edu.tw/java/). Our java applets are ready over the net, easy-to-use and meaningful for many physics teachers, whose primary concern is teaching instead of technology. Learners do not have to sit passively watching the java animation. They are allowed to interact with the animation themselves. It requires learners to constantly make decisions about which parameters to modified and evaluate progress, thus forcing students to apply higher order thinking skills. The size of the java applets is small, usually less than 30k, which is suitable for the overcrowded Internet. Many physics teacher around the world already design worksheets incorporate with our java applets in their day-to-day instruction. Our goal is not only to help learners accomplish their physics learning faster or more effectively, but also to engage them in new ways of thinking, enjoy the funs of physics and apply their physics to everyday life. It can be operated as different kinds of modes, such as studying individually, study cooperatively and having lessons collectively etc. These attributes closely match those of modern educational theories where learning should be a self-motivated and rewarding activity.

Keywords: **Java Animation, Virtual Laboratory, Computer Assisted Learning.**

1 Introduction

Many have predicted that the Internet, particularly the World Wide Web, will transform education. As more schools adopt the internet and more teachers and students become increasingly interested in the web-based activities, the need for easy-to-use and meaningful web learning environments has increased dramatically. At the same time, education research has shown that the learning style and student-centered learning are important to meaningful learning . Learning becomes an active process of discovery and participation base on self-motivation rather than on more passive acquaintance of facts and rules [8]. Current and emerging technological advances in information and communication technology make it possible to develop interactive learning environment to support new ways of learning. The most promising technologies are based on virtual machines, meta-languages, and open Internet standards. Although the Internet lowers the barriers to authoring and distribution of educational software, its ability to deliver active content may, in the long run, be more significant. Interactive learning environments are having an increasing role in teaching and learning, and are likely to play an important role in the future [10]. In particular, those tools that encourage/enhance discovery, creativity, and thinking are very much needed.

One of the most exciting developments is the integration of interactive software into web-based courses using the Java programming language. Many physics teachers and students recognized benefits of using the WWW to enhance teaching and learning, while they were using our Virtual Physics Laboratory (VPL). We have developed more than 60 physics related java applets, which become the core of VPL. Java animations developed at our site offer many advantages for the integration in our didactic concepts: All of our java animations visualize the effects and parameters of the related physics concepts or phenomena. It provides

user to manipulate all necessary parameters in a very intuitive and interactive way. Through modifying these parameters in java animation, students get a much better understanding of the underlying physics and mathematics aspects. Our tools are easy-to-use and meaningful for many physics teachers, whose primary concern is teaching instead of technology. The most important implication of choosing a web-based technology is the way it facilitates sharing. We have received tremendous email feedbacks from physics teachers, parents and students all over the world. Many teachers developed their own worksheets in cooperated with our java applets, and used it in their classroom. Due to the slow connection over the Internet and many requests from educators, our VPL contents were distributed as mirror sites at more than 35 educational institutions around the world.

2 The Learning Process

Traditional approaches to education promote subject-based learning, which encourage teachers to focus on covering materials and students to adopt surface learning which fail to integrate knowledge [3]. When the television was invented half century ago, many had predicted that the television would transform the education. Some people thought if the best teacher were lectured on TV, all the students would be educated under the best environment. We have learned the lesson, teaching and learning is not delivery process between teacher and students. It appears that "learning consists of the growth of additional neural connections stimulated by the passage of electrical current along nerve cells (neurons) and enhanced by chemicals (neurotransmitters) discharged into the gaps (synapses) between neighboring cells" [11,12]. People learn differently and know things differently because they take different pathways on different occasions; which related to the context, their previous experiences, and their physical and emotional state. Not all pathways are accessed in the same way. However, as a particular pathway is re-used, additional connections are built which strengthen the linkages. Some of these mental pathways become so worn that the mind seeks to use these easy routes to arrive at an understanding. In many case, learning means making new pathways, adjusting pathways or removing pathways among memories that become "known" as incorrect. Learning is a personal activity and the function of a teacher is to help student create interaction between subject under studied and student's cognition structure.

The rapid advancement of the Internet, particularly the development and prolific expansion of the WWW, enable educators to create multimedia teaching resources and interactive instructional strategies which can be delivered to any students without regard to time, place, or computer platform. However, the medium of delivery is not the sufficient condition for learning. Education research informs us that technological advances do not necessarily lead to improve learning. Nothing happens until the learning is actively engaged. For today's technology to have a long lasting impact on science education, it will need to base more on successful pedagogy than on the latest compilers, hardware, or algorithms.

Interactive engagement (abbreviated IE) teaching methods take many different formats [2]. All of them, however, force the student to play a much more active role in the learning process, increase the amount of interaction with fellow students and instructors, and emphasize conceptual understanding as well as quantitative problem-solving. Hale's study [1] compared IE methods, with traditional lecture methods at variety institutions, and showed a significant, across the-board improvement in students' conceptual understanding in IE classes. The most dramatic differences are seen in the area of conceptual understanding. The interactive capabilities of WWW-based instructional strategies can be employed to better match how we teach with how we know students learn.

3 Virtual Physics Laboratory: Enjoyable place to play and learn physics

Game playing is a self-motivated and rewarding activity. An enjoyable computer game is found to be player centered, and it must enhance discovery. Learning should be a self-motivated and rewarding activity, too. Can we make learning as motivated and rewarding activity as computer game playing? This was the initial spark for the VPL project, to develop an enjoyable interactive learning environment helping learners to make sense of physics.

Research on animation can be organized according to the purpose of the animation. In general, instructional graphics satisfy five purposes: they are cosmetic, motivation, attention getting, presentation, and practice [7]. Cosmetic and motivation are in the affective domain, while the others are in the cognitive domain.

1. Graphics used for cosmetic purposes are used to "dress up" the text. Unfortunately, learning does not take place directly as a result of cosmetic graphics. Rieber notes, "At their best, cosmetic graphics help maintain student interest. At their worst, cosmetic graphics distract student attention from other important material."
2. Graphics used for motivational purposes, appealing to the viewer's attitudes. It's important for learner to see material as exciting and relevant. Although learners may be motivated by novel graphics, they may also become saturated as they are inundated with such visuals. As a result, motivating visuals can quickly lose their instructional impact.
3. Graphics used to gain attention. Their primary difference from motivational graphics is that they are not designed to influence the attitude of the viewer but rather to focus the viewer's attention. Attention-gaining graphics may directly influence students' learning, thus it is classified according to the cognition domain of learning. A good example is our "Thin Lens Animator"[13] that shows the images of an object in front of a lens as user click and drags the object across the screen.
4. Graphics used for presentation. For instance, our "Pendulum Animation"[14] is not only present a dynamic visual, but also present data. The data is observed to change as the animation is running. Therefore, the learner can make a connection between the state of the data and the state of the animation.
5. Graphics used for practice activities. This purpose is especially suited to interactive computer simulation where learner receives feedback based on his or her input. For example: Users can type in the base frequency and modify different components of higher order frequency with mouse to create new sound wave and hear it instantly in "Fourier Synthesis"[15].

Our Java applets can be used for all the aforementioned purposes. Most of all, we focus more on students' cognition development. The created java applets aim at invite students to develop deeper, more connected understanding of physics concepts. Seeking connections in contrast to the conventional model of learner as receiving information and of instruction as providing information, in short, to promote conceptual change. According to Rieber, there are two prerequisites for animation to have positive effect on learning outcomes: (1) there must be a need for external visualization (2) learning of the described phenomenon must require an understanding of how an object's properties change with time or position. Rieberb recommends, "Animation should be incorporated only when its attributes are congruent to the learning task". That is, the animation may not be an advantage over a static image in all case. We have designed our java applets according to the recommendation. Many physics concepts especially those involve spatial and time variance, such as stationary wave, Doppler effect[16], and so on, are difficult to express clearly in words or in pictures on the blackboard. By means of our animated java applets, drawing or demonstrations, teacher can cut down the lecture time in class and enable students to understand physics concepts more effectively.

Examples 1:Traffic light system (html page 6k, java class files 27k)[17]

Situation: "Would you like to engineer the traffic light system for a one-way street that consists of several lanes along which rush-hour traffic flows? How would you time the onset of green lights at the various intersections? How to apply what you have learned in kinematics to promote the traffic flow? This java applet let you play with it and find out your answer." All the relevant information is provided for students to find out the answer. This is an authentic situation; the underline principle was used in many cities to control the one-way traffic lights. Each moving square in Figure 1 represents a car, its color indicates whether the car is accelerating, moving with constant velocity, or stopped. The height of each blue circle gives information about the velocity of the corresponding vehicle. User can adjust the timing between green light, yellow light and red light, change time delay between successive intersections, … etc. It is a kinematics problem for high school students related to topics in constant motion and motion under constant acceleration. Students can work in-group, discuss with each other, propose solutions, explain the reasons of their predictions, use physics concepts to analyze and synthesis the answer, and run the animation to compare and find out the answer. Many students find it is a fun game to play and they gain deeper understanding of related physics concepts at the same time.

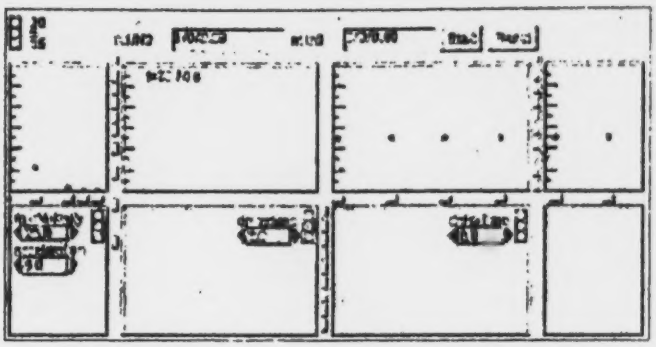

Figure 1: Screen shot of Traffic Light System java simulation

Example 2: Measure your Reaction time (html page 6k, java class files 20k)[18]

Situation: "You are driving on the high way and listening to the music you like most. Suddenly, you see the brake light of the car in front of you just turned on. You will try to hit the brake and slow down your car. But, there is a small time delay before you really do that--- your reaction time. During that period of time, your car is still moving at the same HIGH speed! If you do not want something VERY BAD happened, what is the minimum distance between your car and the one just before yours?" This is a very dangerous situation in real life. However, students can try out such experiments with our java animation safely.

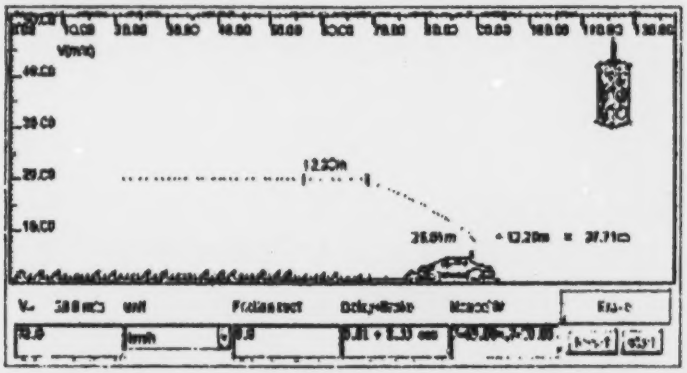

Figure 2: Screen shot of Reaction Time Measurement java animation.

As shown in Figure 2, when the user clicks the button to start the animation, the car will move from left to right at preset constant velocity. The streetlight will turn from green to yellow, and then turn to red light at random selected time. User needs to click the "Brake" button when the red light is on. Those small dots were generated at run time; its height shows velocity of the car at the same horizontal position. Users can move the mouse within the area to find out corresponding value for each dot. Figure 2 indicates the vehicle is moving at 20m/s (72km/hr), arrives at the first red bar when the red light turn to red, and user click the "Brake" button after the car runs 12.2 meter more (the second red bar position). So the reaction time for the user is measured to be 0.61s for this case. It also shows car running at 20m/s need 25.51 m (or 2.55s) to fully stop after driver hit the brake. (Assuming the friction coefficient between the road and the tire of the vehicle is 0.8, which is a typical value for auto tires on dry concrete.) Users can measure their reaction time with this simple java applet, and find out the safe distance to keep when they are driving on the high way. This java applet also reminds users that the braking distance for the vehicle is proportional to the square of the velocity. When you change speed of your car from 80km/hr to 100km/hr, the braking distance increased by a factor of $(100/80)^2 = (1.25)^2 = 1.56$ (velocity increased by a factor of 1.25). Such requirement is a law governs by nature. May be you can miss the speed ticket if the police is not there; however, car accident will happen if not enough distance were reserved for the corresponding speed. This is a very important lesson need to be

learned; it can save people's life.

Most of the functions provided by our java applets are operated with mouse click and drag, ease to use and intuitive. Sound, colors and good animated drawings can attract learners' attention and sharpen their ability of thinking. Many more examples can be found at our VPL. Interaction between the student and the learning materials is essential. For different learning tasks different interactivities are appropriate. The design of java applets focused on promoting students' integrated understanding of physics concepts through the use of carefully designed curriculum. We want to generate sequences of stimuli that can be used either to activate a person's existing mental models or initiate the development of new ones. To enable student to connect new ideas to their existing knowledge, making bridge to connect their own piece of information. Our approach is remarkably different from typical novice strategies where students attempt to mathematically analyze a problem before qualitatively describing it (an approach often called "plug-and-chug" and characterized by the lack of conceptual though during the problem-solving process [9]). Requiring student to consider problems qualitatively has been shown to have a positive influence on students' problem solving skills and conceptual understanding [5,6].

In physics, information about a physics system were represented in many different ways: using words, equations, graphs, diagrams, table of numbers, contour maps, vector plots, and so on. Many students have considerable difficulty, not only with creating these representations but also in seeing how they express information about the system and how they are related to each other. Our VPL can help student conquer their learning difficulty. With so many feedbacks from teachers, parents and students all over the world, we found

1. Applets in VPL can help students make sense of translation among representation: Showing animations of a dynamic system and move the relevant information to a coordinated graph, diagram, or plot can, when used in conjunction with an appropriate lesson, significantly help students develop skills in using different representations to help them make sense of the physics. For examples: "Superposition principle of wave", "Simple harmonic motion" and "Transverse Wave and Longitudinal Wave" java applets.
2. Applets in VPL can help students understand equations and physical relations among measurements. Many students treat equations as if they were only a way to calculate a variable or determine a number as a solution. Physical equations represent relationships between various observations and measurements. We know how the nature operates from those relations. For examples: " Spring Force and Simple Harmonic Motion", "Thin Lens" and "Double Slit (interference) " java applets.
3. Applets in VPL can help students build mental model of physical systems: In some cases, students don't have the experience or imagination to put together what they are reading in the texts and hearing from the lectures into a coherent, sensible picture. They memorize bits and pieces, but because these pieces are not linked into consistent, self-supporting structure, they forget or confuse the parts. Visions of interacting objects having qualities and measurable properties. Producing visualizations that display these characteristics can help students create these mental models. For examples: "The location of an supersonic airplane", "Moving point source (Doppler effect/Shock wave)" and "Propagation of electromagnetic wave".
4. Applets in VPL can give students engaging, hand-on, active learning experiences. Students learn much more effectively when they have control on their own learning. Having animations that students can use to explore phenomenon on their own, can produce more effective learning experiences. For examples: "Reaction time and car accident ", "The electronic multimeter" and " Projectile/Satellite Orbits" java applets.
5. Applets in VPL can serve as a sketchpad on which students can explain and describe their understanding to each other. Educational research shows it is valuable to have students explain what they are thinking, both to themselves and to each other. Two or three students working together to answer questions with a simulation can produce a powerful learning environment. For examples: "Physics of rainbow", "Billiards and Physics" and "Mixing colored light beams/paint pigments" java applets.

4 Future work

When learners are novices in the content area, they may not know how to attend to relevant cues or details provided by animations. Teacher can provide hints or demonstrations in the classroom and find out how the learner operated with the java animation. However, VPL is designed for web access, which allows students' direct access without teacher's guidance. All of our java applets are client-based simulations. We see the needs to establish communication between client and server. We will extend their function to support client-

server communication: to control and synchronize animation running on several machines, to exchange data between distributed applets. Besides, it can be used to monitor how the remote user operated with our java applets, identify when they encounter difficulty for research purpose and provide assistance at the same time. Therefore, our java applets can be used as stand-alone learning tools or as shared animations to support cooperate learning over the net.

5 Conclusions

Many web sites are aimed at providing information while we focus on interactive animations to assist student construct his/her own physics concepts. The VPL offers possibilities to concentrate on student-centered approach for learning. Learners do not have to sit passively watching the java animation. They are allowed to interact with the animation themselves. It requires learners to constantly make decisions about which parameters to modified and evaluate progress, thus forcing students to apply higher order thinking skills. Our java applets are ready over the net, easy-to-use and meaningful for many physics teachers, whose primary concern is teaching instead of technology. The size of the java applets is small, usually less than 30k, which is suitable for the overcrowded Internet. Many physics teacher already design worksheets incorporate with our java applets in their day-to-day instruction. We welcome lectures to translate our web pages into their own languages and share with us. All the labels and texts used in the java applets can be easily changed to local characters with any web page editor. This provides many users at different countries to use our java applets for their teaching and learning. Our VPL can be used as a teaching tool during the lecture or as assignments for the students to play and enjoy learning physics. It can be used in different ways, such as studying individually, study cooperatively and having lessons collectively etc. Our goal is not only to help learners accomplish their physics learning faster or more effectively, but also to engage them in new ways of thinking, enjoy the funs of physics and apply physics to their everyday life. These attributes closely match those of modern educational theories where learning should be a self-motivated and rewarding activity.

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A Distributed Backbone System for Community-Based Collaborative Virtual Universities

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In this paper, we propose a new framework for community-based collaborative virtual universities, which not only support the delivery of knowledge from an expert to a group of learners, but also facilitate the exchange and distribution of knowledge between large and diverse groups of people. We discuss designing and prototyping of a distributed backbone system for community-based collaborative virtual universities, in which computation is effectively used to provide organized proper support for communication, interaction and collaboration between human users and between a human user and the system as well.

Keywords: **Distance learning, virtual university, virtual community, MOO, software agent.**

1 Introduction

Information and network technologies have been changing how people work, live and learn. The so-called Internet revolution has brought great impact on the global society, and is greatly changing the educational systems. In recent years, distance education/learning and virtual universities have been attracting more and more attentions, and play an important role in the educational system revolution for the new coming century.

Virtual universities cover a very broad field. Many research works have been conducted in the domain [1, 2]. However, experiments and experiences have demonstrated that electronic communication in the networked virtual environment has some different characteristics from face-to-face communication in the real world [3]. Many studies have also shown that learning in the networked virtual environments involves approaches that are not typical of general classrooms [4, 5]. It is necessary for a virtual university to have general functions, utilities and resources of a physical real world university available on the networks. However, it is not enough and efficient only trying to move a physical university to the virtual world without considering on the fact that there are great differences between physical and virtual universities.

In this study, we propose a new framework for community-based collaborative virtual universities, which not only support the delivery of knowledge from an expert to a group of learners, but also facilitate the exchange and distribution of knowledge between large and diverse groups of people. We design and develop a distributed backbone system for community-based collaborative virtual universities, in which computation is effectively used to provide organized proper support for communication, interaction and collaboration between human users and between a human user and the system (a networked computer and/or a software agent) as well.

2 Framework for Community-Based Collaborative Virtual Universities

The Internet provides a universal, free, and equal electronic communication environment for people of all ages with different education backgrounds, ability levels, and personal inclinations. It makes knowledge

delivery, sharing and building possible among large and diverse groups of people across the networks.

The central purpose of community-based collaborative virtual universities is to provide a learning environment that widely opens to large and diverse group of people who have the will to learn and to share their knowledge with others across the networks. They are a networked virtual workspace with the time-independent and place-independent access, in which computation is effectively utilized to actively and properly support human-human communication, interaction and collaboration in addition to human-computer communication, interaction and collaboration, towards effectively assisting and enhancing learning activities in the virtual environments [6].

Community-based collaborative virtual universities are participants-driven. That is, participants or learners share a common interest in a topic or area, share a way of knowing and a set of practices [7]. Knowledge is not just delivered from teachers or experts, but also constructed by participants' team works and/or discussions. Community-based collaborative virtual universities support different ways for novices and experts to work in the same environment to accomplish similar goals. They may be large, the task general, and the communication open. Alternatively, they can be small, the task specific, and the communication close.

3 Design and Implementation of the Distributed Backbone System

3.1 Overview

The backbone system for flexibly supporting community learning has been designed so that a learner can navigate through it, select relevant information, respond to questions using computer input devices such as a keyboard, mouse, or voice command system, solve problems, complete challenging tasks, create knowledge representations, collaborate with others, or otherwise engage in meaningful learning activities.

Figure 1 shows an overview of the distributed backbone system for community-based collaborative virtual universities, which have been implemented in MOO (Multi user dimension Object-Oriented), well known as a text-based social virtual reality [8]. Human users and software agents co-exist and interact in the MOO based virtual community. Social interaction between users is actively mediated and facilitated by cooperative agents who support their learning activities in the virtual environments as well.

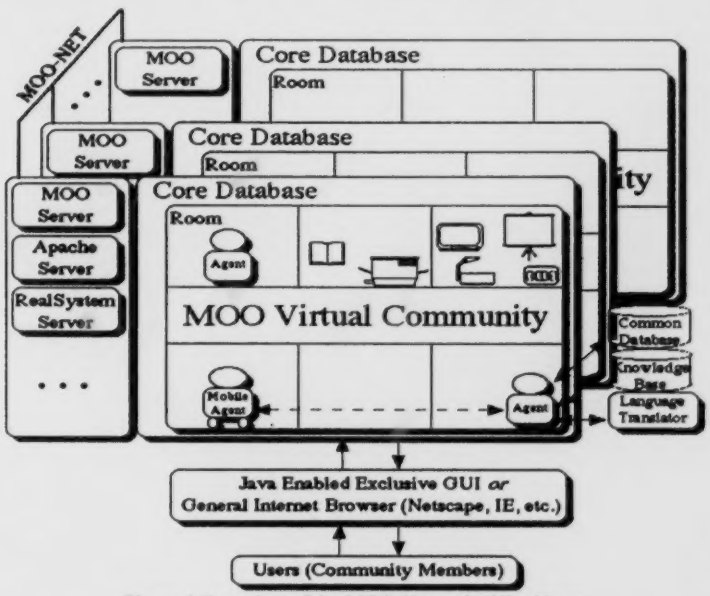

Figure 1 Overview of the MOO-Networked Backbone

3.1.1 Web and Multimedia Integration

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To fully utilize multimedia such as graphic images, sounds, and/or movies, we have integrated the MOO Server with the web server (e.g., Apache Server) and other servers providing multimedia services (e.g., RealSystem Server). Since the seamless integration of the MOO Server with the web server, technically, it is possible to integrate MOO with any types of server services and incorporate any type of multimedia such as MPEG1, MPEG2, and/or MP3 data in the MOO virtual environment.

3.1.2 Graphical User Interface

Java enabled exclusive graphical user interface specially designed for accessing MOO virtual environments has been developed. Consequently, MOO commands and verbs could be transferred to a hyper link. For example, users can go in or out of a room by simply clicking a corresponding hyper link that represents the entrance or exit; they may read a note by clicking the hyper link representing the note. Since it is constructed with Java language, it could be run with a general Internet Browser (e.g., Netscape, Internet Explorer).

3.1.3 Software Agent Support

To further provide flexible and proper support for communication, interaction and collaboration in the networked virtual environments, a multi agent paradigm has been adopted in this study. We have proposed a kind of software agents that adapt well to users' behavior and incorporated them both within the MOO environment and on the interface which we call interface agents, and integrate one interface agent for each user that bridges the virtual environment and the user to aid his/her manipulations and various activities.

Interface agents provide different ways of supports. They may provide suggestions, answer questions to a user. They can search something from an outside database or knowledge base for their owners by ``*wireless*" communication with the DB/KB agent to transfer their owners' request and obtain the search results. Interface agents may accompany a user to move around the virtual environment if the user requests so. They can also provide actively supports to a user once a problem occurs.

In addition to interface agents, there are also various types of software agents inside or outside the virtual community, which are called task agents. Task agents provide specific functions or resources available in the local environment or outside over the Internet to interface agents directly or indirectly. In the latter case, they are mediated by a so-called mediator agent.

3.1.4 Multilingual Environment with Language Translator Agents

Due to the diversity of the users in the community-based collaborative virtual universities, it has to encompass the needs of people of all ages, races, and nationalities with different education backgrounds, and ability levels. Consequently, this causes a language problem in knowledge representation and communication.

As described in the previous sections, integration of MOO environment with the web and multimedia service servers make it possible to play sounds and movies in any language, and display information and knowledge on the Java enabled graphical user interface or a general Internet browser in a language that the client program and browsers may support. However, the language has to be selected and specified by the users themselves. Moreover, it is impossible to conduct real time communication in different languages.

In this study, we have created a new kind of task agents (translator agent) that serves for each users and automatically select one suitable language for the user to communicate with others and browse the information and knowledge in the virtual environment according to the information given in a pre-defined property. The translator agent can also translate for the users from a non-native language to their tongue, even though they understand the non-native language. The agent may also display the original languages that other users speak in addition to the translated language.

3.1.5 Distributed Virtual Environments with MOO-net

To effectively provide general university functions, utilities and resources over the networks, we have designed the backbone system as a distributed one based on the MOO-net mechanism, which is a low-bandwidth information network for the MOO family and operates using a packet-switched model [9]. As a result, distributed virtual lecture could be delivered across the MOO-networked virtual environments using a

special virtual lecture hall. Real time communication could be conducted between users in different MOO virtual environments. Further, agents may communicate with other agents in different virtual environments, and even search objects from there for users.

3.2 Prototyping Implementation of the Distributed Backbone System

The prototype system has been implemented in the three test-beds isMOO (available at URL telnet://n132.is.tokushima-u.ac.jp:6666 or http://n132.is.tokushima-u.ac.jp:6868), izMOO (available at URL telnet://pross50.u-aizu.ac.jp:8888 or http://pross50.u-aizu.ac.jp:7000) and vu21MOO (available at URL telnet://vu21.u-aizu.ac.jp:6666 or http://vu21.u-aizu.ac.jp:6868) which are running under the LambdaMOO Server with the Japanese patch and the JHCore and enCore Databases with MOO-net (http://www.cs.cf.ac.uk/User/Andrew.Wilson/MOO-net/), the RealSystem Server (http://www.realnetworks.com/ products/servers/index.html), and the Apache Web Server (http://www.apache.org/httpd.html).

The LambdaMOO embedded object-oriented script language has been used to construct programs for software agents within the MOO virtual environment, although it is possible and might be more *powerful* to create task agents outside the MOO virtual environment using a standard programming language. Our prototype translator agents support three languages: English, Chinese and Japanese.

4 Conclusion

This study aims at proposing and building an innovative educational system for the coming new century. In this paper, we have proposed community solution as an alternative for virtual universities, and described a new conceptual framework for community-based collaborative virtual universities. We have further introduced design and prototype implementation of the distributed backbone system for community-based collaborative virtual universities.

For future direction, we plan to improve the functions of proper communication support based on studies of natural human communication processes, and design and develop an educational information resource base with high quality multimedia. We will further develop mechanisms that facilitate mutual understanding beyond differences in place, time, language and culture, and make the virtual environments flexibly responsive to users' behavior.

Acknowledgments

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A Java-based Interactive Learning System of Junior High School Level Geometry

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In this paper we propose a Java-based CAI system that provides a learning-by-doing environment with hands-on exercise and instant interaction capabilities on the World Wide Web. Our current topics of interest is the Euclidean geometry for junior high school students. To design the system, we adopt the theory of concept map to construct teaching and learning materials. We are currently testing the system and has observed that it does significantly help students in learning geometry.

Keywords: **CAI, concept map, Euclidean geometry, Java applet**

1 Introduction

As computer science and Internet technology make speedy progress at every moment, computer aided instruction (CAI) plays an important role in our life, especially in future education for global citizens at every corner of the world. Many researches focus on the web-CAI, but there are some drawbacks in these systems:
(1) Some of these systems simply use graphs or animations and text to describe the meanings of the teaching materials. Although this way of displaying is more lively than the traditional textbooks, the learners still need to stare at the screen uncomfortably to read the text thoroughly to understand its meanings. Besides, some subjects such as mathematics need to be learned by practicing with examples.
Plain text reading is just not enough.
(2) Most multimedia web-CAI systems requires high bandwidth, which is still a problem for the current internet infrastructure. Long waiting time for response will definitely degrade the effect of learning no matter how well designed the web-CAI system is.
To demonstrate our ability of conquering the above problems, we have developed a web-CAI system in Chinese (http://www.math.fcu.edu.tw/~tlhorng/geometry) for teaching and learning junior-high-school Euclidean geometry (named just geometry in the following context). Students can have great fun in learning on our system owing to its highly interactive and experiment-oriented features. Besides, the system is designed all using small-size Java applets, and is therefore robust enough to tolerate the usual congestion on the internet.

The rest of the paper is organized as follows: Section 2 introduces our design theories such as the concept maptheory and dynamic geometry method; Section 3 shows the implementation and Section 4 summarizes the whole work and some future enhancement.

2 Theories behind our design

First we employ the concept map theory to plan the curriculum and then apply dynamic geometry method to design the curriculum to be highly interactive, problem-oriented and, most importantly, interesting. In this way, the learners are encouraged to learn by playing with those Java applets, and to construct their knowledge system by concept map theory.

2.1 Concept map theory

In order for learners to make a meaningful learning, Ausubel present a meaningful learning theory [1]. The idea in this theory is that whenever to learn a new concept or a new knowledge it must base on the prior experience. Ausubel's theory considers that the relation between the new concept and learner's prior knowledge plays an important role in the meaningful learning. Whenever the new knowledge, learners' prior concept, and proposition framework are successfully joined, learning is created. In other words, learners can make a meaningful learning by utilizing learners' prior concept to link the new concept to organize the whole knowledge. Novak further presents a concept mapping method for the purpose of verifying Ausubel's theory [1]. Concept map is composed of propositions. Every proposition contains two concept nodes and a relation link between them. In a concept map, concepts are represented in a hierarchical way. A general or summarized concept is put in an upper hierarchy, and a specific or particular concept is put in a lower one. A graph describing the integration of concepts from the lower levels to higher ones and the relation linking among them is called concept map that can represent a knowledge structure effectively.

2.2 Dynamic geometry method

To teach or learn geometry effectively, we usually have the following two aspects in mind [2]: knowledge developing (the deductive method), and knowledge acquiring (the generalizing method).

Both are equally important. However, most of the current geometry curriculum in junior high school has been emphasizing on how to prove a geometric problem by the deductive way, and frequently ignoring how to the generalize a geometry concept by experiments and observation. Our web-CAI system present the curriculum in both ways and particularly emphasizes the latter one.

3 Implementation

In our web-CAI system, the whole curriculum is problem-oriented, and each geometric problem, besides its proof, is designed to be explored by experimentation which is implemented by Java applets. Java applet is selected owing to its full-featured library for designing internet applications and its platform-independent portability [3-5]. The code was written by JDK 1.1 and is entirely in Pure Java™.

3.1 Drawing the concept map

There are four steps to draw the concept map: 1. concept seeking, 2. concept categorization, 3. concept hierarchy, 4. concept relation.

Concept seeking: First list all important concepts to be taught. A concept is the foundation unit stored in the human brain, although everyone may store a same thing by concepts in his own different way. That is why everyone may response differently when seeing or hearing an identical event at the same time. This individual opinion of everybody is called the concept.

Concept categorization: After seeking for concepts, this step is to divide concepts into two parts: event and target. Taking circle as an example in our geometry curriculum, we can list twelve relevant important concepts as categorized in table 3.1

Concept hierarchy: After categorizing the concepts, we further place them into a hierarchy. As mentioned above, a more general concept will be put in a upper level, while a more specific one in a lower level. Figure 3.1 is the hierarchy chart of Table 3.1.

Concept relation: After putting all concepts in a hierarchy, we further denotes those relations among concepts to form a complete concept map. Following the above, the circle's concept map is shown in Figure 3.1.

Event	Target
line	relationship between a circle and a line
chord	relationship between a chord and the diameter
chord and center	relationships between a chord and its distance to center
central angle	relationship between a central angle and a chord
arc	relationship between a chord and a arc
circumferential angle	relationship between a arc and a circumferential angle
tangent	two tangents from an external point to a circle are equal in length
quadrilateral	the opposing angles of a quadrilateral inscribed in a circle is complementary
triangle	three bisectors are concurrent in a triangle
incenter	Distances of the incenter to the three sides of a triangle are equal
two circles	relationship between two circles
two circles and tangent	tow circle' s common tangent

Table 3.1. Concept categorization

3.2 Composing the plan for teaching materials

By the concept map, we can further propose the teaching materials and write down these ideas into a table called the plan of teaching materials. Following the above, Table 3.2 shows a small part of the plan: the relative locations of two circles and their common tangent.

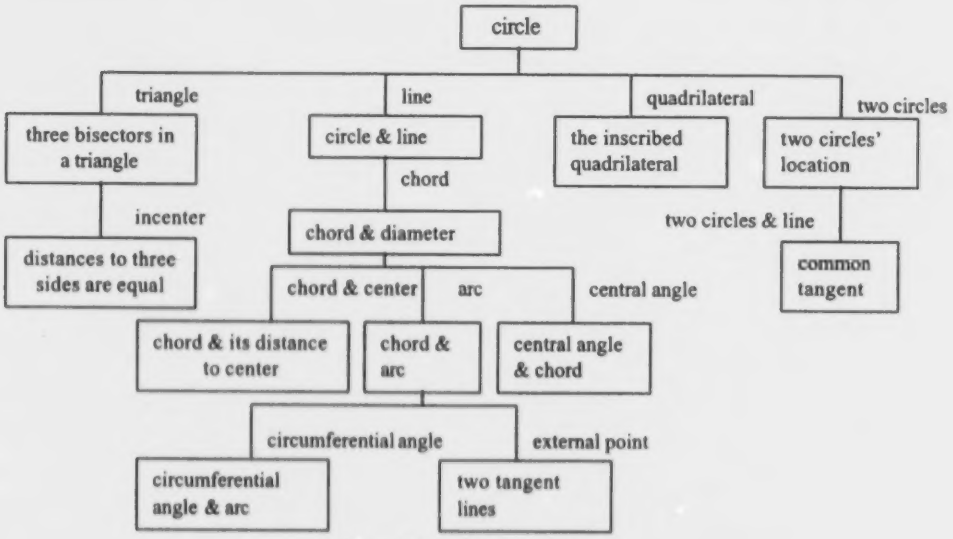

Figure 3.1 Circle' s concept map.

Page	Consist Concept
Circles' locations	There are six kinds of relations for two circles judging from their locations: separated internally, separated externally, tangential internally, tangential externally, intersecting and coincident.
Common tangent	Two circles on a plane can have the following common tangents according to their relative locations: When the two circles are separated externally, there are two external common tangents and two internal ones. When the two circles are tangential externally, there are two external common tangents but one internal one. When the two circles intersect at two points, there are two external common tangents and no internal one. When the two circles are tangential internally, there is only one external common tangents and no internal one. When the two circles are separated internally, there is neither an external common tangent nor an internal one.

Table 3.2 A part of the plan of teaching materials

3.3 Displaying the teaching materials by Java applet

Taking the common tangent of two circles as an example, we display this part of teaching materials by the

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Java applet shown in Figure 3.2 (a)-(c). This Java applet is designed that the learner can play around by dragging any center (shown as red dots) of the two circles which will change the distance between these two centers. From the movement, the learner can observe various kinds of common tangents happening for the two circles. If we show it alternatively by some static graph or animation, the learner would have problem catching its meaning effectively.

3.4 The examination module

Besides those Java applets for displaying teaching materials, our web-CAI system also provides an examination module for on-line testing. Through this module, teachers can edit test problems and grade students' answers, and students can take tests and look up for their grades all on our web-CAI system. Four individual applets, in charge of problem editing, examination, grading, and grade looking-up, consist of this examination module. Figure 3.3 particularly shows the problem-editing part, in which teachers can edit a test problem and draw the illustration related to it. Also, all the test problems can be saved in a database server driven by JDBC• Java Database Connectivity. JDBC is a Java-standard SQL database access interface [6]. It provides access to varieties of databases. After teacher edit the examination questions, the students can take the exam on our web-CAI system. On that, students can write down the answers and draw some auxiliary lines on the illustration which may be required for proving a geometric theory or just to help them solve the problem. Teachers can then grade and comment the students' answers, and the students can look up for the grades and teacher's comment later all on our web-CAI system.

4 Conclusions and future work

We have developed a web-CAI system that provides an interactive learning and testing environment on Web. In this way, the learner can learn more effectively than other multimedia-CAI systems. Currently we have chosen Euclidean geometry in junior high school as an example, and plan to extend to other science subjects, the physics and chemistry in the future. Besides, we keep modifying the GUI in our system to be more friendly and interesting. We also plan to choose a junior high school to test our system and evaluate its performance.

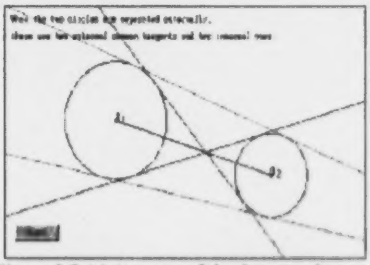

Figure 3.2 (a) A scene of the Java applet of two circles' common tangents. Red points are subject to dragging.

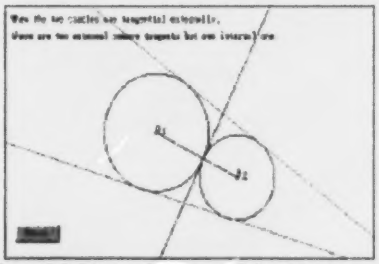

Figure 3.2 (b) Another scene following Figure 3.2 (a).Red points are subject to dragging.

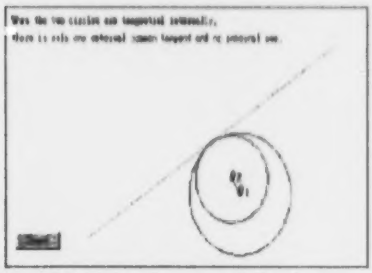

Figure 3.2 (c) Another scene following Figure 3.2 (b). Red points are subject to dragging.

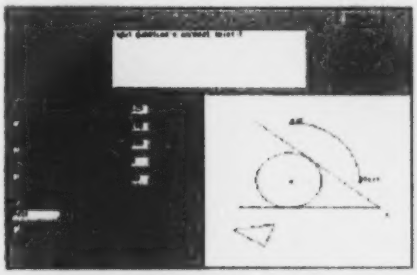

Figure 3.3 Test problem editing part of the examination module.

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A Learning Environment for Problem Posing in Simple Arithmetical Word Problems

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Several researchers indicate that to pose arithmetical word problems is an important way to learn arithmetic. However, the problem posing practice actually is not popular. In this paper, we describe an Intelligent Learning Environment which realizes the problem posing practice. In the problem posing practice, the learners pose problems by using the tools provided by the ILE. The ILE has a facility to diagnose the problems posed by the learners. By using the result of the diagnosis, the ILE indicates whether the problems are correct or not, helps the learner to correct the wrong problems, and provides the next step of problem posing. We used the ILE in three different situations for evaluation. The subjects were elementary school teachers and elementary school students. We also report the results of the evaluation. In the ILE, the interface was implemented in Java, and the diagnosis module was implemented in Prolog. So it can be used on World Wide Web. The current environment deals with simple arithmetical word problems.

Keywords: **intelligent learning environment, problem posing, intelligent tutoring system, interactive education, World Wide Web**

1 Introduction

The main purpose of the practice to solve arithmetical word problems is to make learners recognize the relations between concepts and numerical relations, and master to use the relations. Although the problem solving practice is the most popular way, it is not the only way. Several researchers indicate that to pose arithmetical word problems is also effective. However, the problem posing practice actually is not popular.

The main reason is that the problem posing practice is strongly required teachers to deal with each learner individually in comparison with the practice of problem solving. We aim to realize computer-based learning environments for the problem posing practice [1]. For the problem solving practice, many ILEs are developed so far [2-6]. However, there are few ILEs for the problem posing practice until now.

This paper describes an Intelligent Learning Environment for the problem posing practice for simple arithmetical word problems that can be solved by the addition of one time or the subtraction of one time. The main characteristic of the ILE is the function to diagnose the posed problems. By using the results, the ILE indicates errors in the posed problems and suggests that the next step of problem posing.

Interface of the ILE was implemented in Java, and the diagnosis module was implemented in Prolog. Therefore, if only users have a computer connected to Internet with a popular internet browser, they can use the ILE through WWW: E-mail: nakano@minnie.ai.kyutech.ac.jp http://www.minnie.ai.kyutech.ac.jp/~nakano/problem-posing.shtml (currently Japanese only).

In this paper, the first, the necessity of problem posing and an Intelligent Learning Environment for it are described. Then, interface and diagnosis module of the ILE are explained. The results of preliminary evaluation of the ILE are also reported.

2 Background

2.1 The necessity of an ILE for problem posing

Several researches about problem posing of arithmetical word problems suggested that problem posing was important to learn arithmetic, for example, analysis and investigation about the task of problem posing [7,8], investigation about effect of the problem posing practice [9], investigation in the problem posing practice at arithmetic class [10,11]. Besides, the Curriculum and Evaluation Standards for School Mathematics (in USA, 1989), and Professional Standards for Teaching Mathematics (in USA, 1991) also indicated that it was important for learners to experience to pose problems.

However, the practice actually is not popular in arithmetic class in comparison with problem solving practice. In the practice of problem solving, every problem has an answer and one or a few solution methods. Therefore, the teachers can easily judge the results of problem solving by learners. Then when the answer is wrong, to tell the correct answer or the solution method is not meaningless.

In contrast with problem solving practice, to prepare every correct problem in the problem posing practice is very difficult. Besides, the correct problem that a learner is trying to pose, after depends on the wrong problem posed by the learner. Therefore, the teachers have to examine each problem whether the problem is correct or not, and where of the problem is wrong.

Based on this consideration, we believe that to realize an ILE for problem posing with problem diagnosis function is the promising way to make learning by problem posing popular.

2.2 The problem posing dealt in the ILE

Silver has noted that the term "problem posing" is generally applied to three quite distinct forms of mathematical cognitive activity [12]. They classified three types of problem posing: (1) presolution posing, in which one generates original problems from a presented stimulus situation, (2) within-solution posing, in which one reformulates a problem as it is being solved, and (3) postsolution posing, in which one modifies the goals or conditions of an already solved problem to generate new problems. The problem posing deal in our ILE is (2) within-solution posing. In the ILE, because, in the ILE, first, a learner decides a calculation formula to solve the problem, and next, he/she is trying to pose problem solved by the calculation.

Currently, the LIE can deal with only Change-Problem[13]. In Change-Problem, the quantity in the initial situation is changed to the quantity in the final situation by the change action. The Change-Problem usually consists of three sentences: the first sentence describes the initial situation, the second sentence describes the change action, and the third sentence describes the final situation. Therefore, we prepare a "problem template" that composed of three single sentence templates. By filling in the blanks of three single sentence templates, the problem is completed.

In the ILE, the template of Chang-Problem is composed of the tree single sentence templates that describe: initial situation, change action, and final situation, respectively. The initial situation has the four information: "owner", "object", "number", and "unit". This means that "owner" has "object" and the number of "object" is "number", then, the unit of the number is "unit". The change action has the five information: "actor", "object", "number", "unit", "action". Several actions, for example, "take" has two more information: "from" and "to". The final situation has the four information: "owner", "object", "number", and "unit".

3 ILE for problem posing

3.1 Configuration of the ILE

The current version of the ILE consists of clients and server shown in Figure 1. A client is an interface of the ILE. The interface provides learners the tools to pose problems and gives them guidance to promote problem posing. Inter face is explained in more details in this section 3.2.

The server has two modules: the one is Problem Diagnosis Module and the other is Advice Generator. First, the ILE receives the posed problem, and diagnoses it in Problem Diagnosis Module. Next, in Advice Generator, the ILE generates advice for each learner by using the result of diagnosis. These are explained in

more details in this section 3.3.

Because the ILE deals with several learners by one server, the ILE manages ID, PW, and Learner Model in Private Information Manager.

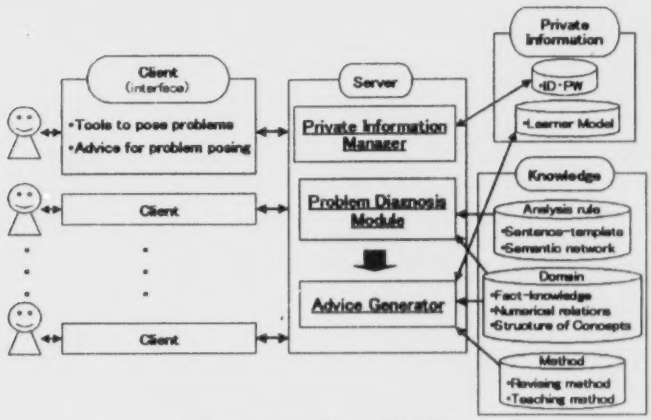

Figure 1: The frame of the ILE

3.2 Interface

Figure 2 shows the interface of the ILE. Current interface deals with only Japanese. In Figure 2, Japanese was translated into English for this paper. The parts of the interface are expressed as follows.

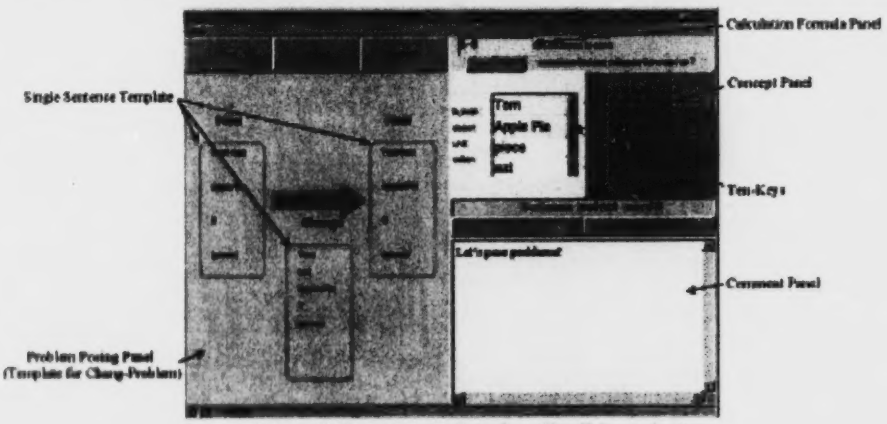

Figure 2: the prototype Interface (English version)

• Calculation Formula Panel

In this panel, a learner gives calculation formula. The learner poses problems which can be solved by this calculation formula.

• Concept Panel

This panel provides concepts to fill in blanks of sentences (three single sentences templates). The concepts that are provided in the Concept Panel are classified in the five categories: "human", "object", "unit", "action", "number".

• Ten-key

Numerical values are put into blanks of sentences with Ten-key.

• Problem Posing Panel

In the current version, this panel provides the template of Change-Problem. The ILE asks a learner to fill in blanks of sentences. In the order of the blanks, the ILE gives questions. By answering the questions, the blanks are filled in. Here, the learner has to select concepts from Concept Panel. By using Figure 3, posing a sentence of initial situation in Chang-Problem is explained. The left side of the figure shows questions.

For example, the initial situation in Chang-Problem is composed of four elements: "owner", "object", "number" and "unit". So, the ILE asks the learner "Who has?", "What the person has?", "How many?", "What is unit?". The learner also should decide what number is the answer by selecting the question mark in Ten-key.

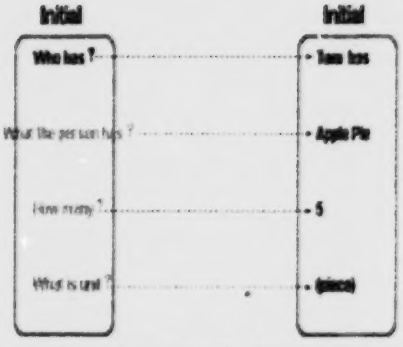

Figure 3: An example of posing sentence by using Single Sentence Template

The right side of the figure shows an example which the learner answered the questions. The result shows "Tom has 5 pieces of Apple Pies".

By answering the all questions, learners pose problems For example, Figure 2 shows the correct problem in Problem Posing Panel: the initial situation is "Tom has 5 pieces of Apple Pies", the change action is "Tom eats the 3 pieces of Apple Pies", and the final situation is "How many pieces of Apple Pies does Tom have?".

• Comment Panel

This panel shows advice and suggestion massages that are generated based on the diagnosis of the posed problems.

3.3 Problem posing in the ILE

A learner poses a problem by the following process.

(1). Giving a calculation formula

First, the learner gives a calculation formula. The calculation formula consists in three elements. That is, two operands and an operator. Because the calculation formula is the way to get the answer of the problem, we call it solution.

The solution can be applied to several numerical relations. For examples, if the learner assigned "5-3" to the solution, the solution can be applied to the following four numerical relations: (a) "5-3=X", (b) "5-X=3", (c) "3+X=5", (d) "X+3=5" (the current version of the ILE only handles natural numbers). Here, numerical relation (a) means the answer is the number in the final situation, numerical relation (b) and (c) mean the answer is the number in the change action, and numerical relation (d) means the answer is the number in the Initial situation.

(2). Selecting concepts from Concept Panel and combining them with the template of Change-Problem

The template has several blanks, and the ILE asks the learner to pose a problem by filling the blanks with the concepts. Then, if the learner selected a concept from the set of wrong concepts, the ILE can give the learner feedback, which suggested that the concept is wrong.

(3). Request to diagnose a problem

When the learner clicks the "diagnosis button", the problem is sent to the server and is diagnosed.

(4). Revising the wrong problem by using the suggestion given in the Comment Panel

When the posed problem is wrong, the learner receives feedback that indicates an error at Comment Panel.

The ILE generates the message by using the result of the diagnosis.

(5). Posing the new problem by using the suggestion

When the learner posed the correct problem, the learner receives feedback which is suggests to pose the new type of problems.

3.4 Problem Diagnosis Module and Advice Generator

Problem Diagnosis Module and Advice Generator are functions of the server in the ILE. Problem Diagnosis Module diagnoses problems sent by the client, and Advice Generator generates messages that are provided for each learner.

The ILE, first, diagnoses a single sentence and then diagnoses the problem composed of three sentences, and compares the solution given by a learner with the problem posed by the learner. In the first step, the module has knowledge about acceptable sentences (initial situation, change action, final situation). We call each sentence "basic relation", and the knowledge "single sentence schema". The single sentence schema checks each basic relation to find the errors in a sentence.

In the second step, the relation among the sentences is diagnosed. The module has the knowledge about acceptable relations among basic relations. We call the knowledge "problem schema". The problem schema checks the numerical relation between the sentences to find the wrong sentence in the problem.

In the third step, the relation between the solution and the problem is diagnosed.

In the following section, the diagnosis process is explained. Then, the feedback made by the diagnosis result is presented.

3.4.1 Diagnosis of the posed problems

Diagnosis of the posed problems is carried out in three steps: the first step is the diagnosis of a single sentence. The second step is the diagnosis of the problem composed of three sentences. The third step is the diagnosis of the relation between the problem and the solution.

(1). Diagnosis of a single sentence

In this diagnosis, two types of errors are detected: (1-a) errors in the relation between object and action, and (1-b) errors in the relation between object and number. Here, Mismatch of blanks (that is, object blank or action blank and so on) and concepts is already checked in the interface.

An example of (1-a) is a sentence that "Tom eats his 2 sheets of postcards." "Tom has 5 cups of apple pies" is an example of (1-b). These errors are detected by checking with sentence schema in that the acceptable relations between object and action or object and number are described.

(2). Diagnosis of problem

In this diagnosis, three types of errors are detected: (2-a) errors in the final situation, (2-b) errors in the change action and (2-c) no relation errors. (2-a) means that the initial situation can be changed by the change action, but cannot be changed to the final situation. (2-b) means that the initial situation can be changed to the final situation, but cannot be changed by the change action. (2-c) means that the initial situation cannot be changed by the change action and to the final situation. These errors are detected by comparing by problem schema in that the acceptable relations among the situations and the change action are described.

An example of (2-a) is the problem composed of the following three sentences: "Tom has 5 pieces of apple pies", "Nancy eats Tom's 3 pieces of apple pies" and "how many pieces of lemon pies does Tom have?" An example of (2-b) is the problem composed of the following three sentences: "Tom has 5 pieces of apple pies", "Nancy eats her 3 pieces of apple pies, and "how many pieces of apple pies does Tom have?"

(3). Diagnosis of the relation between the problem and the solution

The diagnosis module can generate an equation from the problem. In this diagnosis, first, the module solves the equation. Then the calculation to derive the answer is compared with the calculation posed by the learner as the solution. When the two calculations do not correspond, an error in the relation between the problem and the solution is detected.

3.4.2 Feedback for the client

(1). Indication of an error

If the diagnosis module finds an error, the ILE indicates it. Even if the problem includes several errors, the

ILE indicates the error detected first.

(2). Suggestion of the next step of problem posing

The ILE suggests the next step of problem posing when the posed problem is the correct one. In the diagnosis, the module diagnoses not only whether the problem is correct or not, but also what concepts, actions or equations are used in the problem. Based on the results, the ILE can suggest more difficult problem posing by specifying concepts or an equation type to be allowed to use in problem posing.

4 Preliminary evaluations

A prototype of the ILE has been already developed. We used it in three different situation for evaluation, as follows: (1) Use by teachers of the elementary school, (2) Use by students of elementary school in arithmetic classes, (3) Use by students of elementary school outside the class.

In (1), we asked the teachers to evaluate the ILE from the viewpoint of teaching. Then, two of them permitted us to use the ILE in their arithmetic class. So, we had two opportunities to evaluate the ILE in the second situation. In (2), we asked the students of elementary school to pose arithmetical word problems with the ILE in two arithmetic classes. In the trial, although we collected the answers for our questionnaires, we failed to record logs of problem posing. Therefore, we could not get the data about the number of posed problems, and the students behave for feedback from the ILE. In (3), we gathered several students again, and asked them to use the ILE out of class. Here, the students used the ILE for the first time.

In this section, we report these results.

4.1 Use by the teachers of the elementary school

To evaluate a learning environment, the evaluation by teachers is important. We asked five teachers of elementary school to use the ILE. After they posed several problems by using this ILE, we asked them several questions. The questions are as follows: (1) How do you evaluate the effect of problem posing to learn arithmetic? (2) How do you evaluate the way of problem posing used in the ILE? (3) How do you evaluate the interface? (4) How do you evaluate the indications for the errors in posed problems? (5) How do you evaluate the advises to suggest the next step of problem posing? Table 1 shows the results.

Table 1: Evaluation of the teachers

	Good	So-so	Bad
(1)	5	0	0
(2)	3	2	0
(3)	2	3	0
(4)	4	1	0
(5)	5	0	0

Table 1-(1) means that all teachers think to learn arithmetic by using problem posing is effective. Table 1-(2) suggests that the ILE realizes an useful environment for learning by problem posing. Two teachers out of three teachers who answered "Good" to the question (2), gave us opportunities to use the ILE in classes. A few teachers also indicated that the limitation of concepts that were allowed to use in problem posing should be revised. This is one of our future works. In Table 1-(3), three teachers answered "So-so". The result means that the interface is not always easy to use. In Table 1-(4), four teachers answered "Good". The result suggests that the indications for the errors in the posed problem are acceptable. However, several teachers also indicated that the sentences of the indications may be difficult for elementary students. In Table 1-(5), the all teachers answered "Good". This result means that the teachers think the suggestions to make learners progress the next step of problem posing adequately support learning by problem posing.

4.2 Use by the students of elementary school in arithmetic classes

We used the ILE in two classes: the one was composed of 25 students in third grade and the other was composed of 30 students in fifth grade. In each class, 15 minutes were used to explain the use of the ILE, and 20 minutes were used for the problem posing practice with the ILE. In this problem posing practice, students were two people one set, and they operated one personal computer with two. Then two assistants assisted them to operate the ILE in the experiments.

Table 2: Evaluation of the

		Yes	No Answer	No
Third -grad	(1)	22	0	2
	(2)	22	0	2
Fifth-grad	(1)	27	2	1
	(2)	25	4	1

We asked two questions after the problem posing practice: (1) Are you interested in problem posing by using this ILE? (2) Do you want to pose more problems by using this ILE? The result is shown in Table 2.

The results suggested that most students were interested in problem posing with the ILE. But we were not able to get enough data to confirm that the students pose problem well.

4.3 Use by the students of elementary school outside the class

Subjects were one student of fourth-grade, and threes students of sixth-grade in elementary school. In the experiment, we used 15 minutes in the demonstration of this ILE, and 25 minutes in the problem posing practice. The results were as follows. In Table 3, *Diagnosis* indicates the number of time of request to diagnose.

Table 3: Logs of the problem posing

Diagnosis	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
i	α-C	β-C	γ-W	γ-W	γ-W	γ-W	γ-W	γ-W	γ-W	γ-C
ii	α-C	α-C	β-W	β-C	γ-W	γ-W	γ-W	γ-W		
iii	α-C	α-C	β-C							
iv	α-C	β-C	γ-W	γ-W	γ-W	γ-W	γ-W	γ-W	γ-C	

α: A±B=X, β: A±X=C, γ: X±B=C (A,B,C are numerical values. X is a variable)

C: Correct, W: Wrong

In Table 3, equations named by Greek (α, β, γ) specify the type of problem posed by subject. "A" is the number in the initial situation, "B" is the number of the change action, and "C" is the number in the final situation. "X" is the number that is derived by the solution. In the α type, the answer is in the final situation. So this type of problem is the easiest one. In the β type, the answer is in the change action. In the γ type, the answer is in the initial situation. In this order, problems become difficult. The ILE can judge not only "C (correct)" or "W (wrong)", but also the type of problem whenever the student requests the diagnosis.

In Table 3, three subjects (i, ii, iv) tried to pose the problems of the all types, and subject-iii tried to pose the two types of the problems. The subject-i posed the wrong problem of the γ type on the 3rd request to diagnose in the practice. And the subject was repeating to revise it in seven times. As a result, the subject posed the correct problem of the γ type in the 10th trial. And the subject-ii posed the wrong problem of the β type on the 3rd request to diagnose in the practice, then the subject posed the correct problem of the β type in the 4th trial. And the subject-iv posed the wrong problem of the γ type on the 3rd request to diagnose, then the subject posed the correct problem of the γ type in the 9th trial, too. But, the subject-ii gave up to correct the wrong problem of the γ type, although s/he was repeating to revise the wrong problem in three times. The results suggest that the feedback is effective to forward the learner to revise the wrong problem.

In the current ILE, if a learner corrected the problem, the ILE suggests the next step of problem posing. The first step is problem of the α type. the second step is problem of the β type. and the third step is problem of the γ type. In Table 3, all subjects follow the suggestion. In the results, when a learner posed a correct problem, the learner can not poses only the same type of problem again, but also other types of problem by using the feedback. This suggests that the feedback is also effective to advance the next step of problem posing.

Conclusions

5 Conclusion

In this paper, we described ILE for problem posing in simple arithmetical word problems. The ILE provides the template to pose Change-Problem in current version. And the ILE can diagnose the problem that learners fill blanks of the template with several concepts, values, and question mark. Besides, the ILE can support

each learners by using the results of diagnosis. We used the ILE in three different situations for evaluation. In the results, we consider that this research provides basis functions to realize the problem posing practice by ILE about simple arithmetical word problems.

In future work, we will refine functions in the ILE. For example, in the ILE, we will deal with not only Change-Problem, but also the other types of problems. And we will develop a function in which teachers can customize concepts provided for their students in their problem posing practice, because teachers hope to use concepts which are popular in their classroom. Then, we will evaluate the ILE again in order to investigate about the effect to learn arithmetic.

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A Study on the Effectiveness of Web-based Collaborative Learning System on School Mathematics :Through a Practice of Three Junior High Schools

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The topic of Internet for educational purposes is currently hotly pursued but there are still not many observations on the effectiveness of it in school mathematics. In this paper, we discuss the findings of Web-based collaborative learning in school mathematics conducted with three junior high school in Japan, March 2000. Students performed asynchronous collaborative learning using bulletin-board type database installed in a Web server set at the Koshikawa laboratory in Chiba University. Students solved several mathematical problems presented on a Web page while discussing with other students in the database. In classes using the Internet, 3 or more methods of the problem solving emerged in the database as compared with a traditional class, and students could study many mathematical views and conceptions as a result of it. Moreover, a research of the student's opinions after the lessons indicated that students wanted to hear the other students' ideas and views and have collaborative learning, breaking down the traditional concept of the classroom wall barrier.

Keywords: **Web, Bulletin Board, Collaboration, School Mathematics**

1 The background and intention of this research

It is now believed that mathematical knowledge is created through collaborative learning, rather than something individual. This is based on social constructivism in recent years. And teachers have come to accept their new position of an advisor to the students as shown by Vygotsky's "Zone of proximal development".

Through using a distributed network such as the Internet, its very features are effectively utilized and allows the externalization of the student's knowledge. These knowledge can then be shared and this learning method is in accordance with the present idea of how learning occurs[4]. Thus, we have researched on web-based collaborative learning on school mathematics from 1998 focusing on this point[1][2]. With Web-based collaborative learning, it efficiently and effectively overcomes whatever physical differences the students may have and thus widely used for science and social studies lessons.

In mathematics, objectivity is the rule and therefore, there is no need for students to be able to express regional difference clearly and there are not many investigations into web-based collaborative learning of school mathematics. In this paper, we describe the qualities and reasons for conducting Internet based

collaborative learning of school mathematics. We also describe the results of the questionnaire distributed to the students after the lesson.

2 The method of collaborative learning

In this research, we used the "bulletin board[1]" system that can be downloaded free from the Web site. As shown in Fig.1, the discussion progresses by entering in one's idea and posing questions to the others' idea or opinion. Students build their knowledge positively and share them in this process. The discussion is displayed by a tree structure whereby a reply to a question or comment is indicated with a new line, separated from the previous note with a slight space. Each new reply is so indicated, forming a tree structure. The symbol[2] is given to each utterance so that the kind of utterance may be understood. This database was installed in the Web server "Topo" at Koshikawa laboratory, Faculty of Education, Chiba University, and linked to the web page that we refer to as "The Page of Mathematics Teaching-Materials Research[3]". Students used this system for its school mathematicsFig.3. Fig.2 shows the notes which students have entered. Students study, choosing between the two screens, i.e. Fig.1 and Fig.2.

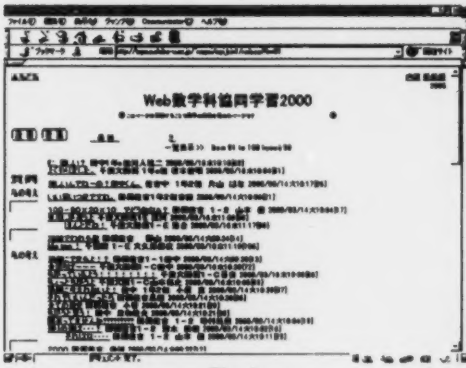

Fig. 1

Fig. 2

3 The outline

The Web-based collaborative learning was performed as follows.

O Student participants

Nagaura Junior High School, 1st grade 2 class

Sumiyoshi Junior High School, 1st grade 3 class

Junior High School attached to Chiba University, 1st grade 3 class

O Term March 2000

O Instruction plan

Each junior high school had a 2 hours lesson.

The 1st hour …Students read the problem and produce their own ideas.
And, they enter in their questions and opinions.

The 2nd hour…Students read the others input and enter in their ideas.
And they continue the discussion.

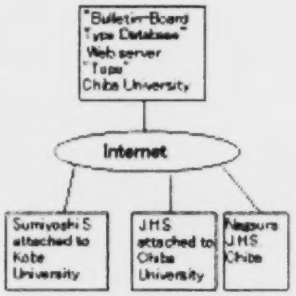
"Bulletin-Board Type Database" Web server "Topo" Chiba University
Internet
Sumiyoshi S attached to Kobe University
JHS attached to Chiba University
Nagaura JHS Chiba

Fig. 3

3.1 Problems given to students

[1] raib-g 2.04 (wakatiai program)

[2] Question="質問"，My Theory="私　考　", etc.

[3] The author's page. http://www2.ak.cradle.titech.ac.jp/nagai/math_room/math.asp

The Grant-in-Aid for Educational Research, Chiba Prefecture(1997), and the Grant-in-Aid for Scientific Research, Japan Society for the Promotion of Science(Encouragement Research B, subject numbers 10913006,1998 and 11913005,1999) are granted to this page.

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The two following problems were shown on the Web page at the beginning of the collaborative learning. Students solved the problem given to them with instructions from the teacher.

○**Problem1**
This year is A.D. 2000. Let's make the following formulas.
(1) The answer is set to 2000, using all the number of 1,2,3,4,～,19, and 20 at least once.
(2) Each number can be used only once.
(3) You may change the sequence of numbers.

○**Problem 2**
How to find, among a set of twelve balls, one which is lighter than any of the other equally-weighted eleven? You have only three chances to use a pair of balances. (Please also consider the reasons and enter it in.)

3.2 The student's activity

First, students read the given problem and create their questions and ideas about the problem. Next, they access the database and enter their notes. They read the others' writing, and if something attracts them, they will write a reply. The activity was performed over 2 hours and problem solving was carried out. A questionnaire shows that students participated in this collaborative learning positively. The teacher's role is only to support the computer operations of the students or problem solving when needed. In the beginning, although there were many students who took time in deciding what to enter or how to operate the database, they got used to it gradually.

4 Analysis and consideration of the collaborative learning

These were two problems and the students solved either one or the other collaboratively. Three junior high schools tackled the problem using the Web-based collaborative learning for 2 hours. Another class was asked to solve the problems not using the Web-based collaborative learning method i.e. traditional method. We describe the difference in the learning produced from the difference between these two methods of instruction. We also analyzed the results of the questionnaire.

4.1 Regarding problem 1

With problem 1, students find as many formula as they can whose answer is 2000 using all the integers from 1 to 20. In the collaborative learning using the Web, students invented 14 kinds of the following methods.

Formulas obtained from the collaboration using the Web (14 methods)

1. 20x10x5x2+(1+3-4)x(6+7+8+9+11+12+13+14+15+16+17+18+19)=2000
2. 20÷10x(19-9)x(18-8)x(17-7)x(16-6)÷(15-5)x(14-4)÷(13-3)x(12-2)÷(11-1)=2000
3. (1+19+2+18+3+17+4+16+5+15+6+14+7+13+8+12+9+11+20)x10=2000
4. (3+5+7+8+11+12+13+14+15+16+17+18+19)x(6-2-4)+20x10x(9+1)=2000
5. 10x20x5x2-(9+6)+(8+7)-15÷3+(1+4)-(11+19)+(12+18)-(13+17)+(14+16)=2000
6. (19-18+17-16+15-14+13-12+11-9+8-7+6-5+4-3+2-1)x10x20=2000
7. 20x10x(1+2+3+4)+(13-6-7)x(5+8+9+11+12+14+15+16+17+18+19)=2000
8. 20x10x5x2+(4-3-1)x(6+7+8+9+11+12+13+14+15+16+17+18+19)=2000
9. (1+3+7+9)÷2x(20+15+5)÷4x(6+14+12+8+11+19+13+17)÷10x(18-16)=2000
10. {10+(11-1)+(12-2)+(13-3)+(14-4)+(15-5)+(16-6)+(17-7)+(18-8)+(19-9)}x20=2000
11. {1+2+3+4+6+7+8+9+10+11+14+16+17+18+19-(5+12+13+15)}x20=2000
12. 20x10x2x5+1x(19+17+16+7+9+3+15-4-6-8-11-12-13-14-18)=2000
13. (1+2+3+4)x10x20+5+6+7-18+8+9-17+16+13-14-15=2000
14. {(11-1)+(12-2)+(13-3)+(14-4)+(15-5)-(16-6)-(17-7)-(18-8)-(19-9)}x10x20=2000

Next, in the traditional class, only four kinds of formulas appeared.

Formulas obtained by the ordinary class (4 methods)

3. (1+19+2+18+3+17+4+16+5+15+6+14+7+13+8+12+9+11+20)x10=2000

10. {10+(11-1)+(12-2)+(13-3)+(14-4)+(15-5)+(16-6)+(17-7)+(18-8)+(19-9)}x20=2000
15. (11-1)x10x20+12-2-4-6+8-3-5+16-7-9+14+15+19-13-17-18=2000
16. (2x3+4+5+6+7+8+9+10-11+12+13+14+15-16+17-18+19)x20÷1=2000

4.2 Regarding problem 2

With problem 2, students find the lighter weight out of 12, using only a pair of balances and within 3 steps. The following four methods of solving the problem appeared in the collaborative learning using the Web. The notation shows how to divide the 12 weights first. For example, "4 4 4" means to divide the 12 weights into three groups containing four weights in each group first.

◇The first division found in the collaboration using the Web

(6 6) (4 4 4)
(3 3 3 3)(5 5 2)

◇The first division found in the traditional class

(6 6) (4 4 4)
(3 3 3 3) (5 5 2) (2 2 4 4)

As shown above, four kinds of methods appeared in the collaboration using the Web and five appeared in the traditional class.

4.3 Analysis and consideration of the data

In problem 2, the variety of methods for solving the problem did not differ much between the Web-based collaboration and the traditional class. However, in problem 1, the number of methods on collaborative learning using the Web was 3 or more times as compared with the traditional class(Exact Probability Test, $p<.05$). For mathematics problems with limited answers, there is not much difference seen between the two methods of instruction. On the contrary, for problems with many possible answer, students achieve better results when they can do the problem solving with the other students through the Web. We definitely believe that the students are able to solve problems by referring to the other student's notes. This can be seen from the student's interaction. For problem 1, five formulas generally represented as "0 × m+2000(m is an integer)" were produced in the collaborative learning using the Web. This is the formula not produced from the traditional class. We consider that the students become aware of this general formula by referring to the others formulas, and they utilize this general formula to solve the problem. Moreover, the students are also influenced by notes such as those below.

First, 20 x(4+6) x(19-9) etc. is calculated, and it is made 2000. Then, it will be set to 2000 if the number which remains is set to 0. Example 20 x(4+6) x(19-9)+(18-17+16-15+14-13+12-11+10-8-5-1) x(2+3) =2000.

2000/03/14 Tuesday 09:25 [9]

Although the formula of this student's example lacks a necessary "7", it is considered that the explanation which means 0xm+2000 was very helpful. This can be read also in the following response to the note " ".

This is a good idea. Every number which is multiplied with 0 is 0. 2000/03/16 Thursday 11:12 [93]

Such examples show that there were some students who didn't only enter their formula, but the strategy as well, and it became a support to other students.

As mentioned above, in collaborative learning using the Web, since the others idea remains on record and can always be referred to, students could utilize this and solve the problem. Problem 1 is asking for many possible formulas whose answers are 2000. That is, we claim that collaborative learning using the Web is effective especially with problems which demand exemplification. And students were able to access many mathematical views and conceptions. This appears also in the result of the questionnaire shown as "Many students' ideas can be known. 49 persons." and "Various methods and ideas which are easy to understand can be known. 36 persons.", and it turns out that the student's incentive and understanding can be improved. These educational effects are obtained by the realization of collaborative learning using the Web, and cannot be obtained in the class which is traditional. We emphasize that the effectiveness of the collaboration using the Internet on school mathematics is demonstrated.

5 Conclusion

In this paper, we referred to the educational effect and influence of the collaboration of three junior high schools using the Web. As we have shown, it has been indicated that students can utilize many mathematical knowledge and conceptions when we use the Web with due consideration given to the type of problems the teacher thinks can extract the most out of the students. This shows that collaborative learning using the Web is useful to train various views and ways of thinking currently emphasized by the Ministry of Education in Japan and National Council of Teachers of Mathematics(NCTM)[3],U.S.A. We emphasize that the database on the Web is effective as an environment where students can tackle open-ended problems in mathematics.Considerations for the future include the improvement of the student's computing skills, the improvement of the system with regards to numerical expressions and careful selection of the kinds of mathematical problems to be given to the students. After all, according to a questionnaire, since it is indicated that 70 percent or more of students are supporting collaborative learning using the Web from various reasons, we want to continue the research wholeheartedly from its educational perspective.

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A Web-based Interactive Exercise System for Learning Mathematical Functions

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1 Introduction

Although exercises are important in learning fundamental mathematics, it is not easy to provide an appropriate exercise for every student in a class because the understanding level and the calculating skill of the student usually differs widely. Computer systems storing problems for the exercises and learning histories of the students might help the situation. The system should also have some intelligence in evaluating students' answers for making it closer to the written exercises and going beyond the multiple choice questions [1].

CAS and graphic calculators have some intelligence in a way. They calculate or operate mathematical expressions symbolically, show the graphs of functions immediately. But the use of them does not always help the students to understand the mathematical concepts or the meanings of the operations [2]. They might become black boxes that hide not only the detailed process of the calculation but also the mathematical ideas lying behind them.

The authors have been developing a Web-based interactive exercise system since 1996 and have been using it as a supporting tool for teaching mathematics to our students [3]. The purpose of developing the exercise system is to change the roles of the students and the CAS. We want the students to think or guess in their exercises and the CAS to assist them for giving some meaningful hints for solving problems by themselves.

2 Interactive Exercise System

The exercise system described in this paper consists of networked computers for students and a WWW server collaborating with a database and a CAS, MATHEMATICA™ as the evaluation engine [4], which allows the students wide variety of mathematical expressions for their inputs. An evaluation is done by MATHEMATICA™ according to the rules described in custom evaluation functions coded with MATHEMATICA™ language [5]. It evaluates the students' inputs symbolically and returns more meaningful comments than correct or not. More detailed description of the structure of the system and some examples of the interactive exercises implemented on it have already been reported [3, 5].

The system, however, needs shorter response time for the exercise of expressing the mathematical function of a given graph. The exercise shows a student a graph of a function, asking to express the function as a mathematical expression (Fig. 1).

It gives the student several input fields for typing his/her expressions in. The expressions are sent to the server and compared with the answer symbolically by MATHEMATICA™. If one of the expression is equal to the answer, a simple comment "right expression" is returned to the student.

If no expressions are equal to the answer, comments describing the difference between the expressions and the answer are returned instead. A graphic image showing both the answer in blue color and the last expression in red color is also displayed, which helps the student to realize the difference visually. Every evaluation gives some hints toward the right expression, which allow the student to learn from his/her

mistakes.

3 Processing Time for the Evaluations

The new exercise needed more evaluation time than the other exercises when Macintosh was used as the server machine. Although the new exercise itself is most popular among the students, the long waiting time hindered it's regular usage. Technically, the biggest difference of the exercise from the others is that MATHEMATICA™ creates a new graphic file dynamically every time at the evaluation and the file is embedded into the HTML for the exercise page. The long waiting time was caused by the process of creating the graphic file.

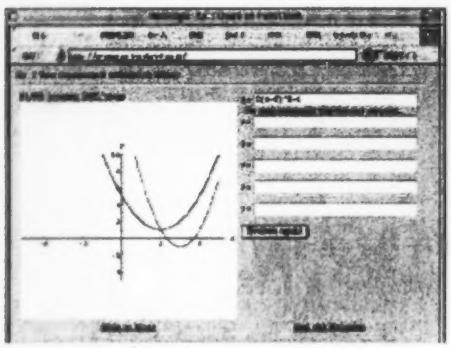

Fig.1 A student' s Web-page after the evaluation

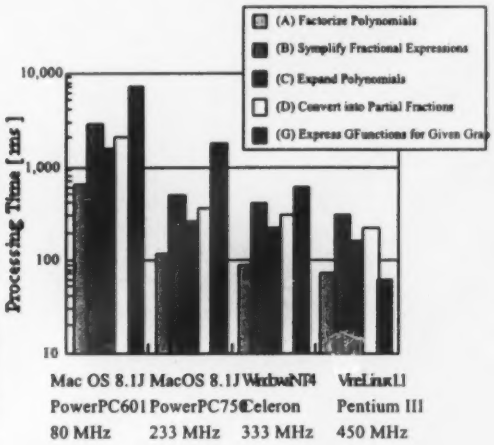

Fig.2 CPUs' processing time for the evaluations

We compared the CPU's processing time needed when MATHEMATICA™ evaluates expressions according to the rules described in the evaluation functions for the system (Fig. 2). There are four exercises of; (A) factorizing a polynomial, (B) simplifying a fractional expression, (C) expanding a polynomial, and (D) converting into partial fractional expressions, each of which needs only symbolic evaluation, and an exercise of expressing the function for given a graph (G) which lets the system create a new graphic file adding to the symbolic evaluation. The measurement was done using several server machines running different operating systems, i.e. Macintosh OS, WindowsNT, and Linux. Although the server machines used to run those operating systems are different in the type of CPU and the clock speed, we thought that the clock frequency of the CPU becomes a rough measure of the performance of a server, which consist of hardware and an operating system.

When we use Macintosh OS or WindowsNT for the operating system of the server, the evaluation of "expressing the function for a given graph" takes more processing time than the other exercises which does not create any graphic files. The processing time decreases with the clock frequency of the CPU and the exercise (G) consumes the longest processing time. If we select a PC running Linux as the server, the tendency is reversed. The evaluation which creates a graphic file becomes the shortest process on the sever while the processing time for the other exercises have same tendency. If we compare the Linux machine (450 MHz) with the WindowsNT machine (333 MHz), the processing time is 1/10 for the exercise (G) while it is 1/1.38 in the exercise (D), and the clock frequency of the CPU is 1.35. Changing the operating system for the server must be the most cost-effective improvement for the response when we put the exercise (G) into wider use.

4 Conclusions

A Web-based interactive exercise system has been extended to serve a new exercise of expressing the function for a given graph. MATHEMATICA™, a CAS used in the system as the evaluation engine, has far

better performance on Linux than on Macintosh OS or WindowsNT for the new evaluation when it creates a new graphic file. The increased performance will make the exercise to be used regularly.

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An experiment of situated learning on college students

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Several experiments of situated instruction have been done in elementary school. We conduct the inaugural experiment on college students. A group of 44 students who are taking food microbiology course involved in this experiment. We designed a science fiction named "Save the Taiwan", which is a story regarding a Microbiology technician handles a disease crisis. A student can learn how to deal with the crisis and solve the problem of an infectious disease when he uses this CAI software. The evaluation practice consists of four dimensions, subject domain demands, instructional demand, user interface demand, and pragmatic demands. The result of evaluation shows notable effect on college students.

Keywords: **situated learning, evaluation of CAI, Microbiology**

1 Introduction

The advantage of traditional instruction is that the knowledge that students learned can be "stiff knowledge". The stiff knowledge can not be smoothly applied to solve the actual problem in a real environment (Brown, 1989). Situated cognition bases on the theory that the learning should be constructed at real situation. Only when the learner derive the knowledge from the real situation then he realizes the real meaning of the learned knowledge and cherish the value of knowledge and take it as the tool for solving the problem. (Cognition and Technology Group at Vanderbilt, 1990)

There was experiment on elementary school student (Tsu, 1997). The experiment was focus on learning simple mathematics calculating. We conduct the experiment on college student, trying to find out if situated leaming can be succeed on the domain of higher education. The students of Department of Microbiology have to take laboratory classes during the period of 4 years college. They always have the problem of how and where to apply what they have learned in the class. The instructive goals of laboratory class are diverse. Lazarowitz & Tamir (1992) believe that learning is a process of construction. Despite of learning the laboratory skill, oral discussion between instructor and students should be part of the learning process. In addition, a more inexpensive and more efficient instruction method, such as computer aided instruction or simulations, should be adapted in the class. Anchored situated instruction adapts computer technology to implement situated cognition theory. (Cognition and Technology Group at Vanderbilt,1990) In our software, we develop a pseudo but can be real situation, embedded the learning materials in the circumstances. Through the interaction between user and CAI software, learner can then practice the process of collecting and filtering information as well as the methods to solve the problem.

2 Design features of our approach

The script was written and designed by a professor of Department of Microbiology. We adopt several principles in our design.

1. Provide vivid circumstance. Multimedia allows us to design a vivid environment, so that the situation can avoid over-simplified and lack of context. (Yang, 1995). Multimedia also provides plentiful visual symbols, e.g. video images, graphic charts, sound as well as text to make the play more fun and close to real environment.

2. To hide useful information in the story, a learner may have trouble to transfer what he has learned to different situation if he was teaching in a simplified or provided obvious cue environment. Whereas, a learner can learn to justify what information can be useful and what information is not useful for solving the problem in a simulated situation.

3. To randomize the plot of the story, the learner can memorialize the plot if he has experienced in using this CAI software. This can then cause the learning process in vain. We use Random function in our design; one of the bacteria was picked randomly and then, in turn, develop different story.

4. To have productive result, there may be only one answer or solution in a traditional instruction. However, in a real environment, there may be more than one solution to solve the problem. They may be pros and cons from one to one, but they may all workable. We do not provide firm answer to user instead, we provide an open-ended environment for user to construct his own path and solution.

3 The story

3.1 Outline of the story

There is a food mediated infectious disease occurs in a small town that locates at the seashore of Taiwan island. Within a few days, this infectious disease has spread to nearby counties and caused many cases of death. Tai-shang (see photo 1), the leading actor, a technician of the local public health administration office, is responsible for finding out the etiologic agent of the disease. In the story, Tai-shang is facing many challenges like the ones in real life. His girl friend, professor and colleagues are all in the plot and interactive with him. After the accident happened, he had faced the pressure from his superior, public media, even from a local councilor. He must acts like a detective who searches the cue and a scientist who seeks for the truth of problem. Finally, with the encouragement of his college instructor, Ta-shang successfully finishes his task.

Photo 1. A clip photo from video " To save Taiwan".

3.2 Goal of learning

a. Cognitive aspect

a. Assessment of identifying the virus, fatal virus can not be classified from appearance. Thus, the learner

has to make a judgement base on the information gathered from the plot and then decide how to proceed the process of bacteria identification.

- b. Learning of the skills of bacteria identification, there are skills, e.g. Stain, biochemical test, can be practiced.
- c. Usage of bacteria identification index table, after the preliminary result of biochemical test, the learner needs to learn to use bacteria identification index table for final judgement.

b. Attitude

- a. Right attitude of science work, through playing the role in the game, the learner can identify the spirit of scientific work, diligence and concentration, as the attitude of being a scientist.
- b. Social caring, since the story has a local background, we hope the learner can improve the caring of local society by solving the problem for local society.

4 Evaluation of our experiment

There are four criteria of the evaluation of the designated software. The criteria is based on the character the teaching subject, human learning theories, and research on user interfaces. Kuittinen, 1998. The criteria consist of four types of requirements: subject domain, instructional, user interface design and pragmatic matters. We invited two batches of domain experts, the faculties of Department of Microbiology and industry professionals to evaluate subject domain. They focused on examining if the concept and methods of this domain are generally applied in our software, which means they checked the relevancy to instructional aims. The group of 20 experts showed their positive opinion at the following chart. Table 1 .The instructional demand is a student-centered approach. We divide a group of 44 college students who are taking food microbiology into two groups. The 22 randomly selected members of test team used our software for average 6 hours in a period of a week. A cognitive examination was taken after one week. The result shows that the test team has better performance in cognitive aspect. Table2. The interactivity, display elements and connections between them are examined as the criteria of user interface. We use questionnaire to test team and found out that the team members show satisfaction of the user interface. Table 3. As the pragmatic criteria, the hardware and software requirements are evaluated to see if a specific and /or expensive equipment or environment is required to use the software. Our software can be used in a common Microsoft Windows environment plus Pentium compatible personal computer. A learner can run our software either at computer room in campus or at his own PC.

Table 1. The result of experts poll

	number	Min	Max	Average	standard deviation	variance
Can the instructional goal of " assessment of identifying pathogenic bacteria " be reached?	12	3	4	3.67	0.49	0.242
Can the instructional goal of " learning the identification methods " be reached?	12	2	5	4.00	0.74	0.545
Can the instructional goal of " usage of diagnostic table for the identification bacteria " be reached?	12	2	5	4.08	0.79	0.629
Can the instructional goal of " influence on right scientific attitude " be reached?	12	2	4	3.58	0.79	0.629
Can the instructional goal of " influence on social caring" be reached?	12	2	4	3.25	0.87	0.750
Does the content of software cover" common foodborne pathogenic bacteria and their characteristics"?	12	2	5	3.92	0.79	0.629
Does the content of software cover" procedures of identification of pathogenic bacteria"	12	4	5	4.33	0.49	0.242
Does the content of software cover" knowledge for assessment of methods used in bacterial identification"	12	2	5	4.17	0.83	0.697

Table 2. Evaluation on the cognitive improvement of the software

Item		n	Average	SD	F-value	df	t-value
Score of Midterm examination	Control group	23	61.96	6.92	2.54	42	-0.34
	Exp. group	21	62.90	11.03			
Semester score	Control group	23	80.09	9.66	1.00	42	1.59
	Exp. group	21	75.48	9.65			
Cognitive Examination	Control group	23	29.74	6.11	1.09	42	-3.14**
	Exp. group	21	41.29	6.98			
Situated Questions	Control group	23	3.57	2.64	1.04	42	-3.73**
	Exp. group	21	6.57	2.69			
Questions on Microbiological Skill	Control group	23	26.17	5.07	1.08	42	-5.47**
	Exp. group	21	34.71	5.28			

Table 3. Evaluation of user interface of the software

	number	Min	Max	average	standard deviation	variance
I do not need tutoring before I use this software	21	2	5	3.95	0.92	0.848
I can easily know how to jump to next screen	21	1	5	3.76	1.18	1.390
I can exit the software anytime, anywhere.	21	2	5	4.52	0.93	0.862
I do not have the situation that I can not proceed because that I did not memorize the previous information while I use this software.	21	2	5	4.19	0.87	0.762
It's easy to modify my answer before I press the "confirm" bottom	21	2	5	4.10	0.94	0.890
I can receive the system feedback anytime when I use the software.	21	2	5	3.90	0.77	0.590
The system feedback is clear enough and no need to be explained.	21	2	5	3.81	0.81	0.662
I can use the software without reading the user's manual in ahead	21	2	5	4.19	0.87	0.762
I think the execution speed is proper to me.	21	2	5	3.95	0.80	0.648
I can handle the execution speed of my own.	21	2	5	3.81	0.75	0.562
I am satisfied the quality of the video.	21	1	5	3.29	1.01	1.014
I can use the software without knowing how to operate Window NT	20	3	5	4.55	0.60	0.366
Total score	21	39	55	47.81	4.12	16.962

5 Conclusions

We completed situated learning software "To save Taiwan" which attract the user to learn the microbiology knowledge and skills. This interactive software provides multimedia and random plots, which enable user to play the role in the story. It can also served as the tool to convey the right scientific attitude and social caring to learners.

The evaluation of this study showed promising results. It is possible and valuable to adapt situated learning to other disciplines in higher education. A disciplinary can construct the learning process on a situated

environment. By using the multimedia software, a learner can learn knowledge as well as the attitude in a near true story. He can then realize the meaning of the knowledge and identify himself with what he has learned and then applied to real environment.

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An Environment for Learning by Design
- In the Case of Learning of Search Algorithm -

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This paper described a learning environment for search algorithms. In the learning environment, learners can build search algorithms by combining several parts by direct manipulation. Then, the environment diagnoses the algorithms in order to give feedback about the algorithms. First, the environment judges whether or not the algorithms are adequate. When the algorithms aren' t adequate, they are diagnosed using heuristics rules. In the diagnosis, errors in the algorithms are detected. By using the results of this diagnosis, the environment can give messages to help the learners revise their algorithms or to motivate them to build the next type of algorithms. We have already implemented the learning environment. As a preliminary evaluation of the environment, we asked 13 students to use the environment, and gathered several types of data. As a result, the experiment suggests that the learning environment is promising.

Keywords: **Learning by design, Error diagnosis, Search algorithm**

1 Introduction

An effective way to learn procedural knowledge in depth is to make learners apply it to various cases. However, although the learners may master how to use the procedure through the experience, it is not enough to answer the question "what the procedure is". Several investigations [1-4] suggested that "learning by design" is a promising way to promote the learner's understanding about "what that is". For example, in order to understand a machine in depth, assembling it from its smaller parts is the best way. In the case of the understanding of procedure, to build up the procedure by trial and error is useful in order to understand it.

This paper reports about a learning environment for learning by design, targeting basic search algorithms taught in an introduction to artificial intelligence lecture, that is, depth-first search, breadth-first search and three heuristics searches (best-first, minimum consuming cost, and A algorithm). In the lecture, usually, the procedure of each search algorithm is taught and learners carry out the searches following the procedures by hand. Some of them understand the meaning of the algorithms through the practice, but some of them only memorize the procedures. Our environment provides several parts of the search algorithm as icons. Learners can assemble them by direct manipulation in the environment. The environment interprets the assembled parts as a search algorithm and diagnoses it, for example, as to whether it falls into the loop or not. Then, the environment gives feedback for the algorithm to revise it or to try to build the next one. The tree structures that are generated as the results of the searches following the algorithms are also presented to the learners. These feedbacks are necessary to realize learning by design effectively.

In this paper, first, the model of the search algorithm that is the basis of the design of this environment is described. Then, the configuration and functions of the learning environment are explained. The preliminary evaluation of the environment is also reported.

2 Interactive Learning Environment of Search Algorithms

Figure 1 shows the configuration of the ILE. It is composed of the interface and reasoning module. In the interface, learners design and build search algorithms, and receive feedback from the system. In the

reasoning module, the algorithms are diagnosed and feedback messages for them are generated. The interface is implemented in Java as a client and the reasoning module is implemented in Prolog as a server. Therefore, the ILE can be used on the Internet.

In this section, first, the model of search algorithms used in the ILE is described. The modeling is indispensable for designing the interface for algorithm building and in order to diagnose algorithms. Then, the interface where learners can build the search algorithms by direct manipulation is presented. The diagnosis of the algorithms and the feedback generated based on the results of the diagnosis are also explained.

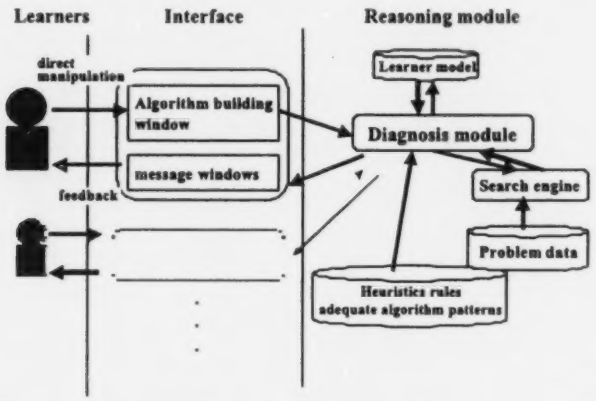


Figure 1. Configuration of the ILE

2.1 A Model of Search Algorithm

Search algorithms taught in the introductory lecture of artificial intelligence share the same procedure as follows. Here, both "Open" and "Closed" are lists composed of search nodes.
1) The start node is put into Open.
2) If "Open == []" then "the end of the search is in failure".
3) Pick up one node at the head of Open (the node is called *n*)
4) If "*n* == goal" then "the end of the search is in successful".
5) Generate child nodes from *n*.
6) Put the child nodes into Open.
7) Put *n* into Closed.
8) Return to Step-2.

The differences between the search algorithms are characterized by the operation of Step 6. For example, depth-first search is characterized as the algorithm in which the child nodes are put into the head of Open in Step 6. Breadth-first search is characterized as the algorithm in which the child nodes are put into the tail of Open in Step 6. In heuristics searches, the way to sort Open is an essential characteristic. In addition, for every algorithm, the method of selection of child nodes to put into Open is also an element that characterizes the search algorithms.

In our system, search algorithms are characterized by the combination of the following three list operations used in Step 6: "selection," "connection" and "sort." There are two types of selection operations: the first is "to select nodes that are not included in a list," and the other is "to select nodes that are not included in a list or are lower in cost than the same node in the list." Connection also has two types. The first is "to put nodes into the head of a list" and the other is "to put nodes into the tail of a list." The referred list is usually Open. We prepared three types of sorts: "to sort in the order of the consumed cost (minimum consumed cost search)," "to sort in the order of predicted cost (best-first search) " and "to sort in the order of the total of the consumed and predicted cost (A algorithm)."

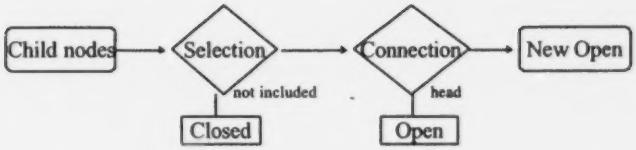


Figure 2. An example of the model of Search Algorithm

Figure 2 shows an example of a search algorithm built by the operations. The lozenge is the operation, and the rectangle is the list. The parameter that indicates "referred cost" or "head or tail" to specify the operator is presented at the bottom right of the lozenge. Therefore, Figure 2 means that "the child nodes that are not included in Closed are put into the head of Open." This is a kind of depth-first search that prunes using Closed.

Every part described above is necessary to build the search algorithms taught in the introductory lecture to artificial intelligence. In order to make learners understand search algorithms more deeply, our ILE provides an environment where learners can build search algorithms freely, and can receive feedback for the algorithms. In the following section, the ILE designed based on the model of search algorithms is described.

2.2 Building Search Algorithms

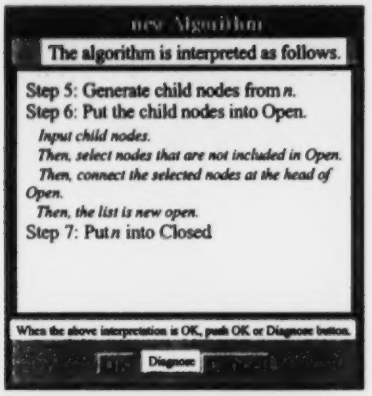
The interface for building search algorithms is shown in Figure 3 (currently, the interface is written in Japanese. Explanations in Figure 3 are translated to English for this paper. Japanese version is shown in [5]). Learners

Figure 3. The Algorithm Building Field.

build search algorithms in the "building field" by assembling parts provided in the interface. At the bottom of the Interface, three operators are provided in the lozenges. The parameters specifying the operators are selected from the menu under the lozenges. The reference lists of the operators are selected from the box at the upper left. All manipulation in the interface can be done with a mouse. The algorithm in the building field is a depth-first search without having pruned.

Learners can confirm the algorithm built by themselves in two ways: a written explanation and a trace of the

search tree. The explanation is generated by interpreting the operations in order of sequence in the building field. Figure 4 is the explanation of the algorithm shown in Figure 3. A search tree is generated by showing the trace results in a search space. The search spaces are provided as mazes in the environment. Figure 5 is an example of search tree that is the results of the search for the maze shown in the right in the figure.


new Algorithm
The algorithm is interpreted as follows.
Step 5: Generate child nodes from n.
Step 6: Put the child nodes into Open.
Input child nodes.
Then, select nodes that are not included in Open.
Then, connect the selected nodes at the head of Open.
Then, the list is new open.
Step 7: Put n into Closed
When the above interpretation is OK, push OK or Diagnose button.
Diagnose

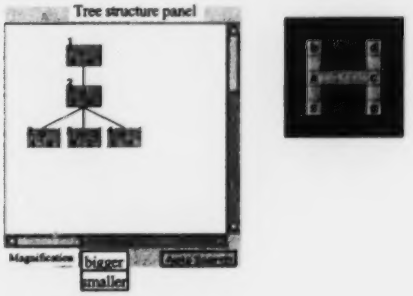


Figure 4. An Example of Explanation an Algorithm. Figure 5. An example of search tree.

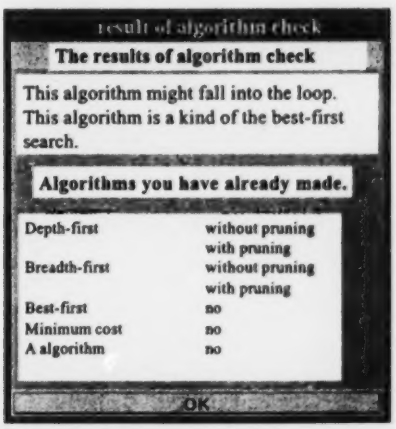


Figure 6. An Example of the Results of Problem Diagnosis.

Learners can also ask the system to diagnose the algorithms built in the building field. The reasoning module has both the adequate combinations of operations and heuristics rules to criticize the algorithms that are not adequate. By using the adequate combinations, the adequate algorithms can be detected. By using the heuristics rules, the errors in the inadequate algorithms are detected. If no errors are detected by the heuristics rules, the reasoning modules can not judge the type of the errors. The heuristics rules are prepared from the following three points of view: the kind of algorithm, redundancies in the algorithm and the covering of the search space. An example of messages generated from the results of the diagnosis is shown in Figure 6. In the following section, the diagnosis of the search algorithms is described.

2.3 Diagnosis of Search Algorithms

In the reasoning module, the algorithms are diagnosed using heuristics rules. The heuristics rules of each viewpoint are shown in this section.

2.3.1 Type of Algorithm

The algorithms built by the learners are categorized by the following heuristics rules.

* When, after child nodes are put into the head of Open, either any nodes are not put into the head of Open or Open is not sorted, the algorithm is categorized as depth-first search.
* When, after child nodes are put into the tail of Open, either any nodes are not put into the tail of Open or Open is not sorted, the algorithm is categorized as breadth-first search.
* When, after child nodes are put into Open, Open is finally sorted in the order of consumed cost, the algorithm is categorized as minimum consumed cost search.
* When, after child nodes are put into Open, Open is finally sorted in the order of predicted cost, the algorithm is categorized as predicted cost search.
* When, after child nodes are put into Open, Open is finally sorted in the order of the total of consumed cost and predicted cost, the algorithm is categorized as A algorithm.

When the algorithm has no characteristics checked by the above rules, the kind of algorithm cannot be specified.

2.3.2 Redundancy of Algorithm

When the algorithms include the following operators, the diagnosis module judges that the operators are redundant in the algorithms.

* The same operators are used continuously.
* When several operators of sort are used, only the operator of sort used at the end has meaning.
* After using the connecting operator with a list as the parameter, the execution of the selection operation with the same list as the parameter results in deleting the added nodes.

2.3.3 Covering of the Search Space

Several search algorithms that can be built by learners can not find goals that exist in a search space. The reasoning module diagnoses whether or not the algorithm can cover the search space, by using the following heuristics rules.

* When several child nodes which might imply goals are not put into Open, the algorithm might fail to reach the goal included in the search space.
* When the algorithm that isn't categorized as breadth-first, minimum consuming cost or A algorithm doesn't include the selection operator with Closed as the parameter, the algorithm falls into the loop.

2.4 Feedback based on the Diagnosis

Based on the results of the above diagnosis with heuristics rules, the messages to criticize the algorithm are provided in the interface. Figure 7 shows an example of the messages. When the type of an algorithm is judged, the type is indicated. When the algorithm includes the redundant operators, the operators and the explanation of the redundancies depending on each heuristics rule are provided. When the algorithm might not cover the search space because several child nodes fail to be input into Open, the explanation prepared for the heuristics rule is shown. When the algorithm might fall into the loop, the possibility of falling into the loop is indicated.

When the algorithm includes a pruning operation, the fact is also indicated. In the interface shown in Figure 7, to motivate learners to build the next algorithms, the algorithms the learner has made correctly and hasn't made yet are shown.

3 Preliminary Evaluation

For a preliminary evaluation of the learning environment, we gathered thirty college students and asked them to use the learning environment. Those who were in the second grade or in the third grade have already taken the lecture of artificial intelligence. Their participation was voluntary. Before the experiment, we explained how to operate the environment for ten minutes. Then, we asked them to build search algorithms in the learning environment for an hour.

In the experiment, we recorded the following data: (1) the number of algorithms built by the learners, (2) the number of adequate algorithms, (3) the number of inadequate algorithms that could be diagnosed with heuristics rules, (4) the number of inadequate algorithms that couldn't be diagnosed, and (5) the number of types of the adequate algorithms the learner made. The results are shown in Table 1. After the experiment, we asked four questions: (a) Are you interested in the system? (b) Is the system easy for you to use? (c) Would you like to use the system more? (d) Do you understand the search algorithms better than before? The results are shown in Table 2.

Table 1. The results of the students algorithm building.

Student number	(1)The total number of algorithms	(2)Adequate algorithms	(3)Inadequate algorithms (be diagnosed)	(4)Inadequate algorithms (not be diagnosed)	(5)the type of the algorithms
No.1	26	11	15	0	5
No.2	24	10	6	8	5
No.3	16	10	6	0	5
No.4	38	17	13	8	5
No.5	44	13	20	11	5
No.6	48	10	26	12	5
No.7	21	8	8	5	3
No.8	26	15	9	2	5
No.9	23	14	4	5	5
No.10	16	5	6	5	1
No.11	43	24	11	8	5
No.12	20	8	12	0	5
No.13	16	9	7	0	5
	361	154	143	64	

Table 2 . The Results of Questions.

	Yes	Maybe yes	No	No answer
Qusetion-a	10	3	0	0
Question-b	1	7	5	0
Question-c	7	5	0	1
Question-d	3	3	4	3

In Table 1, the total number of algorithms the learners made was 361, that is, 27.8 per student. The total number of adequate algorithms was 154, that is, 43 % of the algorithms. The total number of inadequate algorithms was 207 (57%). The number of diagnosed errors by heuristics rules was 143. This means that the system could detect the errors in 69 % of the inadequate algorithms. Among thirteen students, eleven students made every type of algorithm.

In Table 2, the results of Question-a and –c suggest that most of the students had interest in the learning environment. The result of Question-b indicates that the interface is not easy for the students to use. For Question-d, four students answered "no", and three students didn't judge, that is, more than half the students didn't think they gained a deeper understanding by using the learning environment.

Students made many algorithms in the experiment and they answered that the learning environment was interesting. In addition most of them could make every type of algorithm. These results suggest that the learning environment is promising. The answers for Question-b mean we should improve the interface. In Question-d, Six students thought they got deeper understanding by using the environment, but seven students didn't think so. When we gathered students, we told them that we would ask them to use a learning environment for search algorithms. Therefore, most of the students participating in the experiment might have confidence about their understanding of search algorithms. This is one reason for the result for Question-4.

As for the results, the experiment suggests that the learning environment is promising to be used in the real world, but the effect couldn' t be confirmed clearly.

4 Conclusions

This paper described a learning environment for learning by design in the case of search algorithms. In the learning environment, learners can build search algorithms by combining parts by direct manipulation. Then, the environment diagnoses the algorithms in order to give feedback about the algorithms. First, the environment judges whether or not the algorithms are adequate. When the algorithms aren' t adequate, they are diagnosed using heuristics rules. The heuristics rules detect errors in the algorithms. By using the results of this diagnoses, the environment can give messages to help the learners revise their algorithms or to motivate them to build the next type of algorithms.

We have already implemented the learning environment. As a preliminary evaluation of the environment, we asked 13 students to use the environment, and gathered several types of data. As a result, the experiment suggests that the learning environment is promising to be used in the real world and that is promising, but the effect couldn' t be confirmed clearly. In the next step, we will use the learning environment in class and evaluate it in a real learning context.

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An Implementation of Campus Distance Learning System Using Multicast

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A problem common to many universities is that thousands of students want to take some certain courses but only a few can actually take them owing to the shortage of teachers. The Campus Distance Learning System is an important way to solve the problem. This paper starts with an examination of some existing solutions, and then introduces the primary-secondary model multimedia network teaching system designed by researchers in the Computer & Information Management Center of Tsinghua University. The system is composed of three parts: the primary classroom system, the secondary classroom system, and the courseware management system. It fulfills real-time interactive teaching and learning, and multipoint communication, and at the same time records the teaching materials as courseware. The paper focuses on the constituents, structure and characteristics of the system, and expounds in detail the implement technology based on multicast. In the end, the paper points out some problems calling for further consideration.

Keywords: **Network distance learning; primary-secondary model; multicast**

1 Introduction

A problem common to many universities is that thousands of students want to take some certain courses but only a few can actually take them owing to the shortage of teachers. The traditional resolution was videoing and then broadcasting through CATV. This used to play an important part in television education, but it can not support the interaction between the teacher and the students, and the information that is limited by TV is not sufficient for lectures. With the network becoming more and more popular, network education instead of CATV is being received by more and more people. Many companies and universities have developed different network distance learning systems, the following are several famous systems.

Remote Education System of VTEL: This system is an application of the VTEL videoconference system in education. It adopts a complete set of software and hardware developed by VTEL and can implement mulitpoint bi-directional interactive network education.

IP/TV of CISCO: IP/TV is software developed by Cisco company, supporting video on demand and video broadcast. It adopts the client/server model and is mainly used for transferring high quality video, audio and data via computer networks. The system supports three ways of video transferring: live, on-demand and scheduled.

Multimedia Distance Education System of SATCOM: This system includes a program courseware generation system and a courseware on demand system.

2 Primary-Secondary Model Multimedia Network Teaching System

2.1 System Constituents

The primary-secondary model multimedia network teaching system is composed of three parts: the primary classroom system, the secondary classroom system and the courseware management system (See figure 1).

The primary classroom is where the teacher stays. In this classroom, the video and slide of the lecture are recorded synchronously. The video and slide information is broadcast live through multicast, and at the same time the information is stored in the courseware library for asynchronous use.

The secondary classroom is the classroom without the teacher, maybe a remote classroom. Students in this classroom can join the lecture by registering and playing the composite stream courseware synchronously with the primary classroom.

The courseware management system provides the directory service, user register management, asynchronous courseware on demand, and other management functions of the coureware library.

The free terminal can join the lecture from anywhere of the campus network through registering. It can also play courseware on demand from the courseware management system.

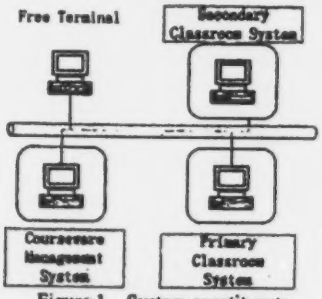

Figure 1 System constituents

2.2 System Structure

Figure 2 shows the structure of the primary-secondary model multimedia network teaching system. Its subsystems are as follows:

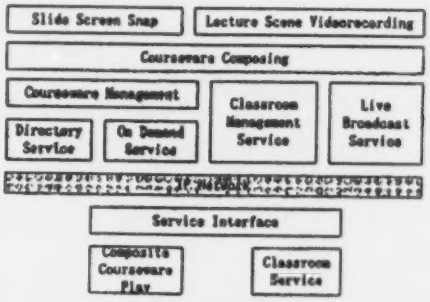

Figure 2 System structure

- Courseware synthesizing: The courseware synthesizing is the kernel subsystem of the primary classroom system. In this procedure, both the basic materials of the courseware – lecture scene videorecording and slide screen snaps are compressed into the composite courseware with synchronous timestamp. Afterwards, the courseware is stored into disks and multicast at the same time by the system.
- Lecture management service: The lecture management service is anther important subsystem of the primary classroom system, its main functions being registering new courseware in the courseware management system, requesting for the multicast address, configuring the multicast scope and lecture management.
- Directory Service: This is the kernel function of the lecture management system. It provides lectures and courseware lists and user management.
- On-demand Service and Live Broadcast Service: On-demand service is an asynchronous courseware service provided by the courseware management system while live broadcast service is a synchronous

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service provided by the lecture management system. Both of them provide composite stream courseware to the user, the former using unicast and the latter using multicast.

- Lecture Service: This is an interactive supporting system provided by the secondary classroom system. With it students in the secondary classroom can participate in the discussion. The means of interaction may be keyboard typing, and speaking with a microphone.

2.3 System Characteristics

The main characteristics of the primary-secondary model multimedia network teaching system are the following:

1) It uses two streams to play the teacher's videorecording and slide screen snaps, and the quality of the slide screen snaps is the same as that of the slides in the primary classroom.
2) The lecture scene is kept in the archives in real time, and can be replayed at any time.
3) The teacher can discuss with students in remote classrooms through videoconference, and they can write on the same electronic white board.
4) The audience can have interlocution with the lecturer by text typing.

3 Implementing the System with Multicast

3.1 The Multicast Technology

By keeping routers informed about multicast hosts, multicast datagrams can traverse an internetwork and reach many hosts simultaneously. The ability to traverse an internetwork and reach an unlimited number of "member" hosts simultaneously without affecting others adversely is the linchpin of multicast. A Class D IP address in the range from 224.0.0.0 to 239.255.255.255 is a "multicast address." Each is also known as a "host group address," since datagrams with a multicast destination address can be received by all hosts that have joined the group that an address represents. Figure 3 shows the datagrams spreading abroad.

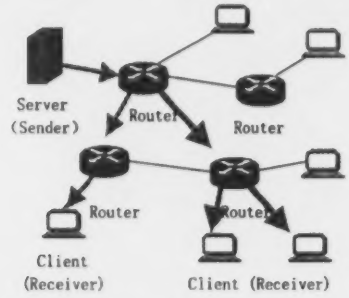

Figure 3 Datagrams sent only to hosts in a group

The mechanisms incorporated into WinSock 2 for utilizing multicast capabilities can be summarized as follows:

- Three attribute bits in the WSAPROTOCOL_INFO struct, which are used by **WSAEnumProtocols()** to discover whether multicast communications are supported for a given protocol;
- Four flags defined for the *dwFlags* parameter of **WSASocket();**
- One function, **WSAJoinLeaf()**, for adding leaf nodes into a multicast session;
- Two **WSAIoctl()** command codes for controlling multicast loopback and the scope of multicast transmissions (SIO_MULTICAST_SCOPE and SIO_MULTIPOINT _LOOPBACK).

We can benefit from using multicast to implement network teaching system, which can be described as the following:

1) Because the member of a multicast group is dynamic, and no authority is requested, the terminal can join or quit a group at any time;
2) All hosts belonging to a multicast group have a clear physics network topology;
3) All users in one subnetwork that join the same multicast group share the same stream over network, and this can greatly lighten the network load.

3.2 System Implementation

In the practical system, we adopt the combinative way of multicast and unicast: using multicast to broadcast information from the primary classroom, and using unicast to implement the interaction between the primary classroom and the secondary classroom. Figure 4 shows the structure of the practical system in detail.

The primary classroom system is composed of a server, a teacher's PC, a video recorder, two overhead projectors and an electronic white board. The teacher's PC is used to play slide of the lecture, and it projects the slide to the electronic white board. If the teacher writes something on the electronic white board, the teacher's PC will capture the written information and combine it with the slide. At the same time, the teacher's PC compresses the slide/written information and sends it to the server. The server takes charge recording the video/audio information, receiving the slide/written information from the teacher's PC, and broadcasting the information with multicast. At the same time, the server stores all information into special type file, which is the composite courseware.

The full function secondary classroom is made up of a server, a video recorder, two overhead projectors and an electronic white board. The server receives the video/audio and slide/written information from the primary classroom, and projects the video information on the white wall, the slide/written information on the electronic white board.

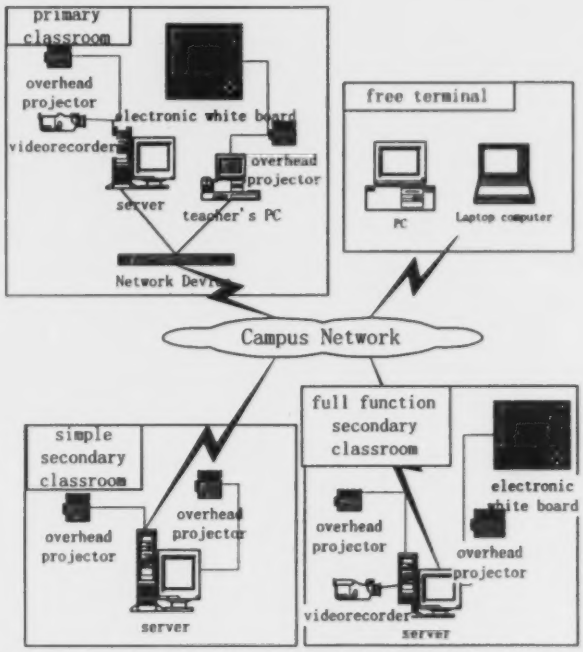

Figure 4 The topology of the primary-secondary model multimedia network teaching system

The simple secondary classroom is made up of a server and two overhead projectors. The server receives the video/audio and slide/written information from the primary classroom, and projects the information on the white wall separately.

The free terminal may be any PC connected to the network. It receives the video/audio and slide/written information from the primary classroom and displays it in different windows.

The teacher in the primary classroom and the students in the secondary classroom can discuss with each other. This is implemented with unicast. During the discussion, the server in the secondary classroom records the information of the students and sends it to the server of the primary classroom. The server of the primary classroom receives this information and projects it on the white wall. If students in the secondary classroom write something on the electronic white board, the servers will transmit the written information,

which will be shown on the electronic white board of the primary classroom at the same time.

4 Conclusions

In our experiments, we use lossless a compression algorithm and the slide screen snaps can be compressed to 1%~2%, it means that the slide screen snaps will take up 100~200Kbps bandwidth. In another side, the video information can be compressed into 128Kbps by MPEG-4 and all the information of this system can be fit in a 384Kbps channel. This system is available for long distance learning and of course for campus distance learning.

The primary-secondary model multimedia network teaching system has built a virtual network classroom system. It will play an important role in making better use of teaching resources and improving teaching efficiency.

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An Interactive Game System to Stimulate Word Associations

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We present here an interactive game system designed to stimulate user's knowledge associations between words. The system is based on a word-association television game called "Himitsu no Tsunagari". This game uses two different words and an association word. Each player is given a word, and must guess the other word and the association word to win the game. Our system allows person-to-person matches and person-to-computer matches. We believe that our system stimulates the users' creativity and their ability to form associations. Our system also acquires knowledge of word associations from game records. As more and more games are played, the system's knowledge of associations grows, and so does its ability to compete with the user.

Keywords: **Educational game, Interactive learning, Knowledge acquisition, Word association.**

1 Introduction

Many games have been designed to enhance various human abilities. Saeki [8] has pointed out that educational software needs to motivate learners in order to attract and retain their attention. If only its appearance is attractive, learners tire of the software soon. One approach developed in our lab to motivate children is the "Instruction Assisted Computer" (IAC) paradigm [4]. In this paradigm, the system is given a passive role and the children are put in the driver's seat. The result is that the familiar roles of teacher and pupil are reversed, and it is the children who end up 'teaching' the computer. To date we have successfully developed and studied several different systems using this paradigm [3][6][8].

Associations between words and concepts form a major dimension of human knowledge. Stimulating these associations can greatly influence concept formation and increase one's problem-solving skill [1][9]. Models based on association networks have been used for vocabulary acquisition [5] [7], and many association word-games have been developed [2].

In this paper, we describe a system to play an association game called 'Himitsu no tsunagari'. This game requires the player to think of several concepts at once and look for associations between them. We believe that this stimulates various associations inherent in the user's knowledge. Our system allows a user to play with another user (on the web, so that two users do not have to be in the same place), or with the computer. It also has a knowledge acquisition module, which analyzes the associations created in each game. These associations are added to the system's knowledge base, and result in a gradual improvement in the system's performance. In the rest of this paper we describe our system and the results of our initial experiments.

2 A Brief Introduction to Himitsu no Tsunagari

Himitsu no Tsunagari is a television game show in Japan. It is an association game using two different words (called 'keys') and another word that is associated with both keys (called a 'link'). There are two teams and a judge. Behind each team, a key is hidden (see Figure 1), so that each team can see the opponents' key, but not their own. Neither team can see the link. The goal of the game is to find their own key and the link. Each team takes turn guessing answers based on the visible key and the past guesses of the other team. The judge provides an evaluation of each guess ('correct', 'close', etc.). For example, in the second row in Table

1, Team B can infer that their key is something "yellow" from Team A's previous answer.

The associations between the keys and the link are not limited to those semantic or conceptual, but can be of any kind. For example, in Japanese "Niji" serves as a link between the keys "14 o' clock" and "rainbow" because both keys are homonyms of "Niji".

3 Design and Implementation of the system

Here we describe the interactive system for the Himitsu no Tsunagari game. We first describe the goals of our system. Then we explain the rules of the computer game, which are a little different from those of the TV game. Thirdly we present an outline of our system and discuss the relations among various modules. Fourthly, we describe the reasoning and knowledge acquisition modules in more detail. Finally, we describe the interface of our system.

Table 1. Flow of a game (Topic : keys - banana and strawberry, association - fruit)

Team	Visible key	Answer (Key)	Answer (Association)
A	Banana	Sunflower	Yellow
B	Strawberry	Lemon	Sour
A	Banana	Grapefruit	Fruit
B	Strawberry	Pineapple	Fruit
A	Banana	Raspberry	Fruit
B	Strawberry	Banana	Fruit

3.1 Design goals of the System

In order to allow many people to play and enjoy our system, we set the following design goals:

- -The game can be played on the Web.
- -The computer can be one of the players.
- -The system has an easy-to-use interface.

3.2 The rules of the computer game

We clarified and added some rules to the TV game rules, as explained below.

- The game is played with two players and one judge
- At the beginning of a game, each player is given a key and the judge is given both keys and the link.
- The judge evaluates each guess as 'correct', 'near miss,' incorrect', or 'strange'.
- Each player is allowed 90 seconds for making a guess.
- The game is finished when the judge declares the guesses of the key and the link as correct.

3.3 Overview of the system

The structure of our system is shown in Figure 1. There are five modules in it: game server, user interface, knowledge acquisition, reasoning module (making guesses), and knowledge database. The game server is responsible for sending the keys and the link to the players and the judge, and for passing messages (guesses and evaluations) between the players and the judge. The words used in the game and their associations are saved in the knowledge

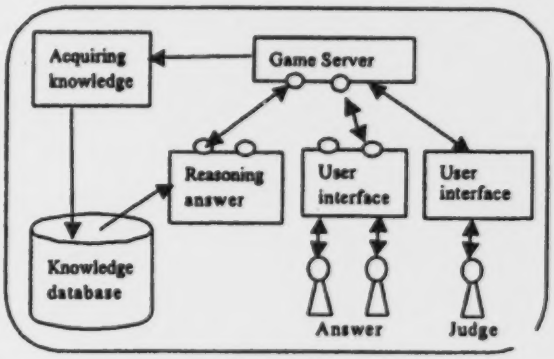

Figure 1. Structure of the system

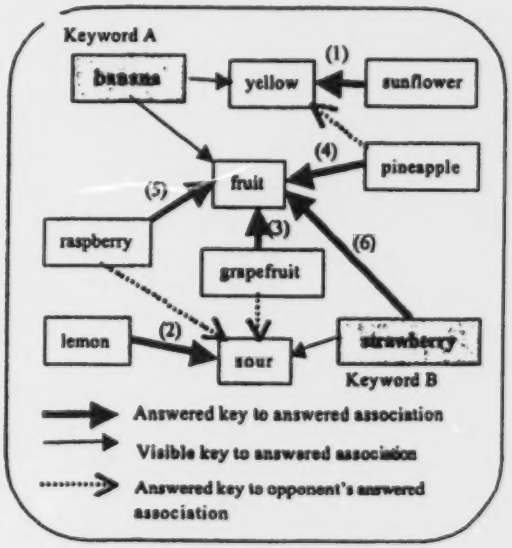

Figure 2. Association network from a game.

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database. This knowledge is used to make guesses when the computer is one of the players.

3.4 Acquiring and Reusing Knowledge

We describe here our approach to acquiring knowledge about word associations from past games, and using this knowledge to make guesses in subsequent games.

3.4.1 Knowledge acquisition from past games

From the record of a game we can make an association network (Figure 2). It is difficult to say from the record which guesses of the opponent were useful for a player in making his or her own guesses. For example, when the opponent's guess seems quite unrelated to the visible key, a player may just disregard it. However, we assume that the link and the key in each player's guess are associated. We also assume that the link in each player's guess is associated with the key visible to that player. So we add <guessed-key, guessed-link> (⟶) and <visible-key, guessed-link> (⟶) to our set of associations in the knowledge base. We call each of these pairs an "association pair", and the network created by all the association pairs an "association net".

3.4.2 Reasoning Module: Guessing the key and the link

As mentioned above, we assume that the link guessed by a player is associated with the visible key and the guessed key. For this guess we make two assumptions: the guessed link is correct or incorrect, and the guessed link has something to do with the hidden key. For example, if the opponent guessed "the key is 'apple' and the link is 'red'", and it was judged incorrect, a player can infer that the opponent's visible key (and the player's hidden key) is associated with red and the correct link is not "red". From these two pieces of information we can search for plausible answers in the association net (Figure 3). Every time the opponent makes a guess, the computer searches the association net and adds a certain weight to each plausible association pair. When it is the computer's turn to make a guess, it selects the association pair with the highest weight.

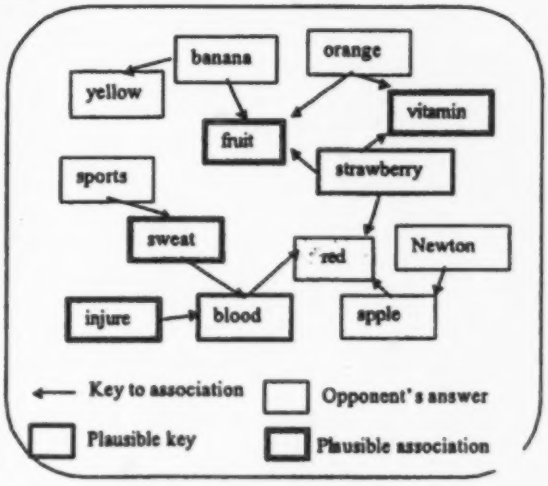


Figure 3. How to search for plausible answers

3.5 Interface

There are two displays, one for the judge and one for the players. They differ only in the input area. The player-interface displays the visible key and the history of the game (the player's guesses, the opponent's guesses, and the judge's evaluations), and has areas for entering the guessed link and key. The judge-interface is similar except for the input area. Instead, it has eight buttons (four each for the key and the link) at the bottom of the screen to evaluate the players' guesses. There is a time limit of 90 seconds, after which an answer is sent automatically.

4 Experiment

We tested our system with 10 undergraduate students in the Computer Science Department. In the beginning, we explained how to play the game with various topics and a sample game. Then subjects were matched to a computer to play the game using ten topics for two hours. Assistants judged the games. Subjects sometimes thought deeply and sometimes seemed to hit upon an idea quickly. We acquired about 1,400 answers. Here is a result of one game (see Table 2).

After playing the system, we let the subjects explain from which words they guessed the answers. We used their explanations to determine from how many words an answer was guessed • we call this the 'base-words number'. For example, "wiener" was guessed from "coffee" and "hotdog", so the base-words number is 2. The average base-words number was 1.4. This result shows that users try to consider more than one word in playing this game.

Some subjects tended not to answer within 90 seconds. Such subjects were found to have a higher base-words number than those who answered in time.

Table 2. An example, "Wiener & Twins". Both concepts also called "sohseiji" inJapanese

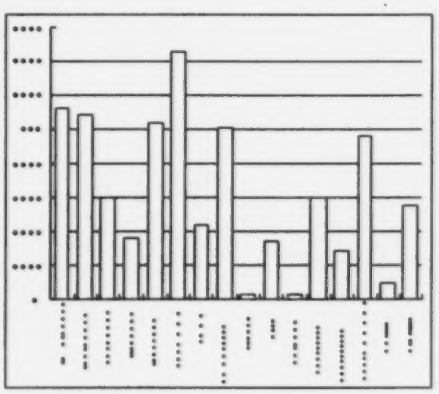
Turn	visible key	Key	Association
Computer	Wiener	American	Coffee
Subject	Twins	Haliwood	Shuwalzneger
Computer	Wiener	Ketchup	Hotdog
Subject	Twins	No	No
Computer	Wiener	Salami	Sausage
Subject	Twins	Wiener	Sausage

We categorized the associations into 16 groups (Graph 2), most of them from Togawa's classification. Superior, inferior, instance, synonym, same, emotion (<magic, muse>), character (<apple, red>), character2 (<Wright, airplane>), component (<sausage, pork>), inclusion (<apple, pineapple>), junction (<sun, flower>), place/time, phonic, verb, target (<knife, apple>), ellipsis (<wolf, liar>wolf boy lies a lot). Synonym was the most frequently guessed category. Ellipsis association represented 5% of the guesses. We think that playing with the system stimulates many kinds of associations.

We also gave a questionnaire after playing the game. In spite of its free answer form, most players answered that they enjoyed thinking and the moment of hitting upon an idea.

5 Conclusion

We described an interactive system using the Himitsu no Tsunagari game. In this game a user can play against either other users or a computer player. The computer uses the knowledge acquired from past games. It improved itself by acquiring knowledge from game records. Users tried to answer using associations to 1.4 words on average and in various categories. In addition, they said they enjoyed thinking about the answers in the experiment. We believe our system stimulates users' ability of associating words. Since many games were played, the computer acquired sufficient knowledge to compete well against users.



Graph 2 Categories of associations

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An on-line ITS for elementary algebra

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The objective of this research is to reinforce the concepts and procedures of elementary algebra that students learn in junior schools. Students react to teacher's instructions in various way. However, in a traditional class, the ratio of teacher to student is still too great. The question of how to help all the students with limited number of teachers arises. This paper describes how to achieve the above objective with the help of an intelligent tutoring system. It discusses the design outline and the system architecture of the proposed system. The tutor tracks student's performance and uses this information to provide most suitable instruction to each student dynamically.

Keywords: **Web-based learning environment, intelligent tutoring system, elementary algebra**

1. Introduction

In a class of forty students, it is hard for teachers serving every student's questions within a class of forty minutes. Teachers teach students concepts and methods or techniques to solve problems in group. Then related exercises are given to students to practice at home. Students who have no doubts in class might cope with the exercise and learn well while some might not master the technique that teacher has taught. They always frustrate when they cannot solve the problem. In this situation, some advice from teacher is very helpful in their learning process. However, teachers are not always available while they need help. Also teachers might not be able to answer many students' doubts at the same time. This research is conducted with the aim of using computers to support the knowledge acquisition process that is adjusted to the capabilities of individual student. Students just need to have a web browser to connect to school network and would get assistance right away.

Many existing CAI applications do help a bit in students' learning process but they do not consider the background knowledge of students. This means that they might provide inappropriate feedback to students which in turn affects student's progress in learning. In order to overcome this situation, research has been investigated on intelligent tutoring system which includes functions for guiding students towards proper knowledge acquisition, according to observation of the student's problem-solving process and identification of the causes of student error.

We first depict the learning environment of our system in section 2and then the overall architecture of our system is mentioned with detail description of main components of ITS in section 3. The final section concludes our work.

2. Learning Environment of on-line ITS for elementary algebra

ITS for elementary algebra is designed as a problem solving environment to be used in class. Therefore we assume that student is familiar with the basic concepts of elementary algebra and know the ways to factorize a polynomial. Students use the system as a tool at home or during class practice. Since the condition that students

use it lacks teacher's support, an interactive problem support should be built into the system. With this feature, students might get help on steps of problem solving where he has difficulty.

In order to access the on-line tutoring system, a student just needs a web browser and types the address where the system locates. An instance of the system will be created in student's computer in the form of ActiveX control. Although it might argue that there is great network delay in loading the system in student's computer, interactivity and userfrindliness deserve a short delay. In fact, in a local environment, the network traffic is not so congested. Therefore this is not a real problem. Instead, students can use it as if any Windows program and do not have to worry about its maintenance or compatibility issues. The control serves as a communicator betweent the system and the student. It transfers student's action to the system and returns the reponse of the tutor to the student.

Every student has his own session during the learning process. When a student enters the system with his user name and ID, a model of student performance is created or opened to set his learning environment. ITS selects a problem according to student's level for him to work or waits for the student to enter a problem which he has doubts. In both situations, the student solves it with the guidance of the tutor in a step-by-step way. The system keeps track of every step of the student in background. If nothing goes wrong, it remains quiet otherwise it prompts student's error. His problem solving procedure is kept in the system for future reference.

3. Overview of on-line ITS for elementary algebra

Our system follows the standard architecture of client-server model. The system resides on the server side. The basic components of the learning system are the domain module, pedagogical module, student modeler and the interface.

The domain expert module consists of two main programs. One is a problem solver which is capable of solving problems in its knowledge base. The other one is question generator that creates new problems according to the instruction of pedagogical module. In order to achieve its mission, the knowledge base is composed of both rules and cases. The expert model is capable of solving general problems by the rules coded in its module. As for miscellaneous problems, they are indexed as cases with problem characteristics and solving techniques so that the domain expert knows how to retrieve the relevant solving technique with the detected problem features.

The domain that we have chosen is factorization of algebraic polynomial for students in elementary classes. Given a polynomial, factorization is to express an integral polynomial as a product of prime polynomial. Therefore a polynomial is not completely factored unless each factor is either a monomial or a prime integral polynomial. Generally, there are 4 basic methods to factorize an algebraic formula. They are: (1) obtaining the common factor (2) using identities (3) cross-method and (4) divide the polynomial into groups and then simplify groups to find factors.

The pedagogical goal is to let junior students master the methods to factorize a polynomial smoothly. Students are taught the basic method to factorize an algebraic formula. However, they always get lost in the actual application to find the factors of a given formula. Therefore, we have organized the pedagogical knowledge by constructing groups of problems according to the level of difficulty, problem characteristics and solving technique. Within each level, there are pre-requisite question types which a student must understand before a certain question type will be generated. Figure 1 shows part of the relation among question types. There are several groups having polynomial problems as bellows:

- Problems, which just need one method to solve. They are polynomial with common factors, problems that satisfies the characteristics of perfect square: $(a\pm b)^2 = a^2\pm 2ab+b^2$, difference of 2 squares: $a^2-b^2=(a+b)(a-b)$, sum or difference of 2 cubes: $a^3\pm b^3 = (a\pm b)(a^2\mp ab+b^2)$, or perfect cube: $(a\pm b)^3 = a^3\pm 3a^2b+3ab^2\pm b^3$ and problems of trinomials with a degree of 2 i.e. $x^2+(a+b)x+ab = (x+a)(x+b)$
- Problems that need 2 methods to solve are posed, for example: ab^2-4a. There are a few combination of solving techniques like common factor with standard equation, common factor with cross method or cross method with standard equation.
- Problems with more than 4 terms that need to be divided into groups of terms before they can be solved by the general methods.
- Problems that require special techniques to solve like adding terms, splitting terms etc.

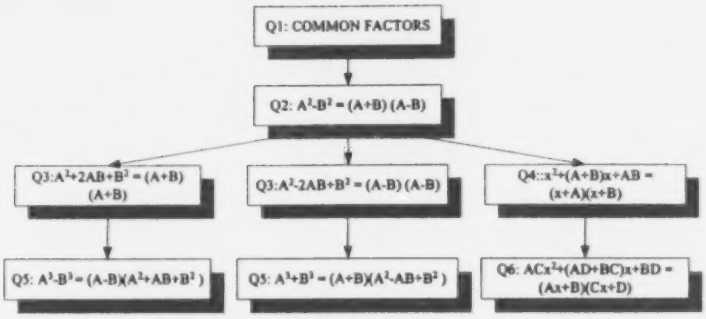

Figure 1. Part of the pedagogical knowledge

A student modeler tries to understand the mental state of a student so as to provide a more accurate estimation of individualized instruction. The task of building a student model is extremely difficult as the amount of information to capture is huge. Although it has been pointed out that this task is intractable[1], an incomplete student model is still very useful in the process of tutoring [2] [3].

The student modeler evaluates the solution of the student and the ways he factorizes the polynomial with respect to the one solved by domain expert. Although the solution path for a given problem of a student might be different from that of domain expert, the student's solution is still correct if it answers to the problem. In our case, if all the factors that the student found are irreducible, his answer is correct. The tutor would suggest him another way to solve the problem if it is found that his solution path is different. In this way, students are guided to know that there is always another way or a better method to solve a problem. Referred to table 1, student is asked to factorize a problem $4a^2-16b^2$, the second column shows the ways that he solves the problem. The student answers the question correctly and his student model is updated accordingly. Although his problem solving procedure differs from the sample, this would not affect his student model. Only the tutor would suggest him its way for the student as reference.

Problem: $4a^2-16b^2$			
Student	Reason	Tutor	Reason
$=(2a-4b)(2a+4b)$	$a^2-b^2=(a+b)(a-b)$	$=4(a^2-4b^2)$	Common factor
$=2(a-2b)2(a+2b)$	Common factor	$=4(a+2b)(a-2b)$	$a^2-b^2=(a+b)(a-b)$
$=4(a-2b)(a+2b)$	Multiply numbers		

Table 1. Procedure that the student and the tutor solves a problem.

The student model in ITS for elementary algebra contains a general information about the student, history of student's performance such as previously solved problem, information about the usage of factorization techniques and what kind of problems he is able to solve according to the pedagogical knowledge. All these information is important to allow students to receive more instruction and perform more problem-solving questions in areas in which they are relatively weak. An array of integer is used to keep the system's belief of student's mastery of a certain skill.

The interface of our system shown in Figure 2 is designed to be user friendly. It is divided into 3 main regions: upper part shows "Check answer" and "New problem" buttons; lower part is the area where the tutor provides feedback. The student interacts with the system mainly at the left side of middle part of interface. He may enter a question by himself or the system might generate one based on his experience. A list of actions is listed for him to explore the problem solving technique. He may select an action to tell the system how he would solve the problem. Every action selected would be given an appropriate feedback to the student. In this way, he might discover what is the consequence of selecting an action. An input area is allocated for the student to enter auxiliary data needed for his selected action. When the answer button is clicked, the student's solution is evaluated and his student model is updated accordingly.

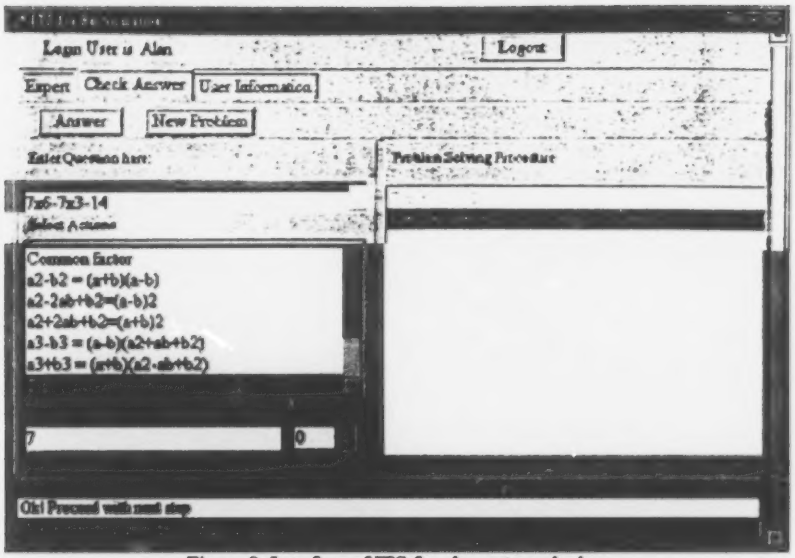

Figure 2. Interface of ITS for elementary algebra

3.1 Evaluation

In our experiments to simulate the problem solving procedure of students using the system, we found that it follows the overall design. It is able to provide individualized instruction, appropriate feedback and model student's performance. For major types of the factorization problem in junior school, the tutor is able to solve and guide the students. However, there are also questions that it fails to solve and guide. There are also cases that the available action for students to use in the problem solving process is not enough.

4. Conclusion

In this paper we have described an on-line intelligent system with interactive problem solving support and curriculum sequencing. A prototype system designed with some learning theory is implemented. The system helps students to reinforce the factorization technique. Our intention of building this system is to increase the learning progress of students and it shows to be a successful tool according to informal evaluation

Since the success of an ITS depends greatly on the student model, we are planning to improve our system with a more accurate student model in the near future. The user interface will be reconstructed to improve the interactivity between users and the system. The implemented domain knowledge is quite limited in this stage and we are developing larger domain knowledge.

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Designing for Interactivity

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In education, 'interactivity' is the catalyst that has transformed the traditional classroom setting into an active media environment. Yet the standards for interactivity within education are by no means clear. Educators and multimedia designers are confronted with many questions concerning the effectiveness of interactive courseware as a learning tool. In this paper, the authors draw on their experience of producing the interactive courseware package *Virtual Language University*, an interactive multimedia package for language learning that has over 3,500 interactive tasks. Specific topics in the paper include screen design, navigation, effective task writing, choices in the type of user feedback, scoring and testing. Attention is given to decision-making procedures that deepen understanding, promote interactivity and encourage self-direction.

Keywords: **interactivity, multimedia, courseware design**

1 Introduction

In education, interactivity has transformed the traditional classroom setting into an active media environment. As Laurel indicates, interactivity is a necessary component for learning to take place. Learners only learn how to learn when they are actively and continually involved in the learning process [13]. Yet the standards for interactivity within education today are by no means clear. Educators and multimedia designers are confronted with questions concerning the effectiveness of interactive courseware as a learning tool, such as: how multimedia can be successfully integrated into the classroom, what level of interaction should be included, and which programs are most suitable. As this new area of learning evolves, those involved in interactive learning are discovering that developing material according to a multimedia interface is simply not enough [25]; [26]; [5]; [3]. Courseware designers are being challenged like never before to produce material that deepens understanding, promotes interactivity and encourages self-direction.

In this paper, the authors draw on their experience of producing an interactive courseware package to discuss the primary areas involved in designing a multimedia program in a Higher Education institution. A review of multimedia production discourse will be used to connect the discussion to broader issues within educational technology and interactive learning. Attention will be given to the decision-making procedures that add to an enhanced level of interactivity within computer-assisted learning.

2 Development Environment

2.1 Virtual Language University (VLU)

Virtual Language University (VLU) is an interactive learning program developed at the City University of Hong Kong. The courseware consists of four CD-ROMs and aims to provide a self-directed learning tool for students and academic staff interested in improving their English skills. The two-year long project was

funded by the Teaching Development Grant of the University Grants Committee. The development team that was responsible for creating the program was an eclectic international mix, consisting of a project manager, three computer programmers, a graphic artist, two scriptwriters and several student helpers. This team worked closely during every stage of the production, including the conceptual phase of brain-storming and scriptwriting, and the production phase of computer programming, video recording, and graphic design. The program was completed after an extensive review and piloting process that took several months.

Figure 1: VLU Campus Map

Figure 2: VLU Lobby

Upon entering VLU, users are introduced to four units: Listening, Writing, Vocabulary and Grammar, metaphorically represented as four separate buildings in a virtual university campus (See Figure 1). The animated host, a friendly Dr. Einstein, provides first time users with a tour of the campus and explains how the program works. Once the users have selected a building (or unit) to work in, they are given a test and provided with feedback on weaknesses before being directed to the appropriate level: 1, 2, or 3, with 1 being the easiest (See Figure 2). For example, the Listening Unit consists of five multimedia lectures from University professors, which include video, graphics, sound and about 40 tasks per lecture. Users can control the forward, back and replay buttons of the lecture, and in this way monitor their own pace and approach in a "learner controlled" environment [5]. Within the Writing Unit, a video tutorial by an actual English teacher guides the students through complex writing structures, pausing for interactive tasks along the way. The other sections, Grammar and Vocabulary, provide ample practice for users to improve their proficiency in grammar usage and to expand their vocabulary. In total, there are over 3,500 interactive tasks in the program, all of which are programmed to give immediate or delayed feedback and a percentage score after each task. Users can also access their last two scores, as this information is automatically stored in the computer.

2.2 Project Development

Developing a multimedia product calls for a collaborative effort from various team members drawing from different backgrounds. The team usually includes a project manager (who is often the instructional designer), a subject-matter expert, scriptwriters, computer programmers, graphic artists, a videographer, an audiographer and administrative support [2]; [15]. The success of an interactive learning product depends very much on the ability of the team to work together; "As multimedia development demands the cooperation of many highly skilled and talented individuals, division of responsibilities, smooth communication, and strong commitment to the objectives of the project are essential to make a project successful" [15]. Depending on the size of the team, one person may take on several roles throughout the course of a project, or roles may overlap - as was the case for the production of VLU.

The project manager addresses the conceptualization stage [[9] and plans the instructional design. This involves a critical look at the educational needs, the interface design and a proposal for the delivery

content. The project manager will identify the instructional goal of the program, which should define, in general, what the program intends to achieve [2]. At the same time, s/he will determine the learning characteristics important to the design, such as the level of instruction, language, age and culture of the end users. The project manager is also responsible for outlining the schedule for the project and may facilitate a liaison with external specialists. S/he coordinates the efforts of the team, encourages positive interpersonal communications, and ensures that team members stay on track and complete their part by specified deadlines [2]; [15].

The scriptwriter works with the project manager to develop the content and design of the final product. S/he is responsible for selecting appropriate media, writing tasks, creating storyboards as well as developing ideas for graphics. Together, the project manager and scriptwriter construct the skeleton for the project, which is then brought to life by the programmers and graphic artists. The early phase is probably the most important stage of the production - and, if done properly, can save hours of time in unnecessary programming and tedious revisions.

Once the programmers and graphic artists have the scripts in hand, they can proceed with the production phase. They may use a number of authoring programs, systems or languages to implement the suggestions of the scriptwriter and project manager [2]. The graphic artist designs the program's graphics and animation, working closely with the scriptwriter to ensure everyone is thinking in the same direction. The videographer collects and digitizes video and photo images and the audiographer records the necessary sound elements. In the case of VLU, university professors were videotaped professionally. Academic lectures were given on different topics, such as "Exploring the Internet", "Organizational Behavior" or the "Poetry of Cavafy". The scripts for the lectures were first written by the professors and then transformed into an interactive format by the scriptwriter and project manager. The professors also acted as the subject-experts of the team, providing specialized feedback during the piloting of the program.

2.3 Scriptwriting

The key to good interactive multi-media packages is the nature and level of interaction between the users and the application. The level of interactivity is directly related to the successful creation of appropriately placed tasks that range in nature and content. During the scriptwriting stage, decisions concerning the number and type of tasks, the style of feedback, the sequence of questions, the different levels of tasks and the type of scoring are made. The decisions should first be organized into an outline form to give a broader perspective and to ensure there is an appropriate distribution among all the categories. It is also important for scriptwriters to maintain consistency throughout the scripts with the use of identical terminology, predictable sequences and the same command language.

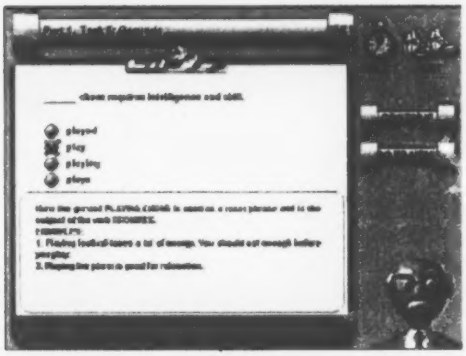

Figure 3: Grammar

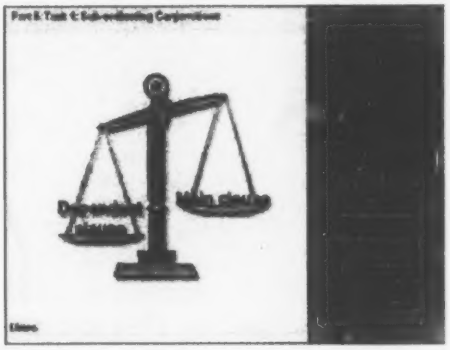

Figure 4: Writing

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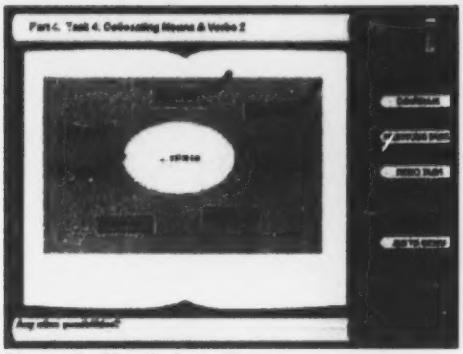

Figure 5: Vocabulary

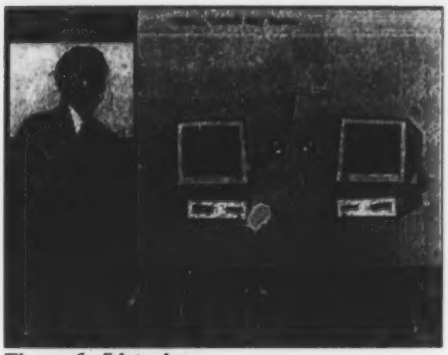

Figure 6: Listening

In VLU, tasks were written according to the instructional aim of each of the four units (See Figures 3-6). The main types of tasks that were used include click, drag, notepad writing and multiple choice. Multiple choice and click are the easiest to construct, both for the scriptwriter and programmer, but should be combined with other task types to ensure maximum interactivity. Each task is designed according to the learning objective of the unit. For example, in the Listening Unit, tasks are diagnosed as vocabulary, main ideas, key words, summary, predictions or inferences. When choosing the frequency and placement of tasks, Orr, Golas & Yao [17] advise including an option for an interactive task every three of four screens, or once every minute. Yet designers should avoid a strict adherence to any formula for interactivity, as it depends entirely on the content, style and complexity of the material being presented. "You cannot gauge the amount of active involvement in a technology product by the number of mouse clicks, and ..similarly, one cannot assess learning by overall level of activity" [26].

The binary structure of the computer makes the process of task-writing an interesting and difficult endeavor. The scriptwriter is faced with the challenge of creating insightful, thought provoking tasks that elicit predictable, quantifiable responses. Where a teacher may be able to judge the validity of a multiple range of answers, a computer cannot. It is therefore up to the scriptwriter to predict all of the potential responses, a challenge especially for tasks that allow users to type responses in an open-ended format. During the piloting of VLU, for instance, it was observed that certain open-ended questions caused frustration among students who believed their answer to be correct - and if judged by a real-life teacher, may well have been. It is for this reason that questions with vague, complex or multiple responses must be constructed with great care.

How, then, can multimedia tasks be written without oversimplifying multifaceted and in-depth subject matter? This has been one of the leading criticisms of multimedia development as it expands to cover the more concept-based material within higher education. Users may get an unwarranted sense of having mastered a complex subject after correctly answering a complete set of computerized quizzes and close-ended questions [14]. One method of avoiding such a compartmentalization of information is allowing students to write down their own opinions on a profound subject matter using a computerized notepad. In VLU, this non-graded task is used to elicit predictions of what the lecture could entail, or personal opinions that the student may have. In this way, students are encouraged to contribute their own ideas and thus are able to build confidence in their analytical skills. The producers of the interactive multimedia package *Investigating Lake Iluka* argue that the notepad facilitates cognitive self-management by allowing students "to collect and manage information from a variety of different sources" [6]. This is substantiated by Laurillard [14], whose case study found that students appreciated "being forced, or perhaps enabled, to consider and develop their own analysis first, before seeing what the expert has written".

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Applied the Gray Relationship Matrix and Learning Obstacles Analysis on the Discovery Teaching

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At recently year the research of teaching method are trending to request the student for active learning, to avoid the student to learn the stuff knowledge. Therefore the number of researchers in the constructivism and cooperative learning etc fields are many. Even now how to estimate the student's learning attitude belong an active type, is a big problem. In our research, we recur to the simple method, adopt the discovery teaching. Because under the discovery teaching, the student does not only use his ground knowledge, but also need face the problem's stimulation and bring the solution. This method can mostly saturate the today's teaching trend. But how to analyze the student's learning obstacle area and supply the explanation to help him cross over the learning barrier is a net bottle in the discovery teaching. In this paper, connect the concept graph and the gray decision-making to issue the gray analyzing method of learning obstacle. This method has a flexible ability to point out the area of learning obstacle, it also can infer the student inbuilt concept or relationship on his knowledge structure. Finally, according to the expert's experiments rule to clearly distinguish the core of problem. Then the system obeys the inferring rules to bring the explanation and the similar question to stimulate the student to build his whole knowledge. This learning cycle will continue until the student completely finishes his learning.

Keywords: **Discovery Teaching• Gray Theory• Concept Graph• OO**

1 gray relational concept graph

a. The design of cognitive structure

Induct the student to learn the material, not only implant him a located knowledge, but also hope he can actively learn or construct the knowledge. Therefore, our system want to stimulate the student, and hope he use his langue or letter to descript his thinking. It like he uses his symbols to review the content and build his cognitive structure. Therefore in our system, our chapter designing does not like traditional, we use the proposition to build concept graph.

Table 1 the relationship matrix

relation / node	Node 1	Node 2	Node 3	Node 4	Node 5
Node 1					
Node 2					
Node 3					
Node 4					
Node 5					

1 encode

2 sort• count

3 semantic• count

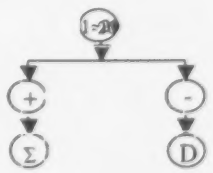

Fig. 1 Concept Garph

b. Relational concept graph

From the cognitive structure graph we can understand that the relation be assembled by node linking to other node, of course each relation also has its particular mean. And in our system the question is based on proposition, then accord with the problem's subject the expert can distribute the weight to each node and each relation. These data can be consisted a matrix, and we call this matrix as the conceptual relationship matrix.

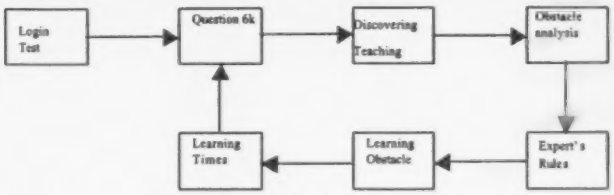

Fig. 2 System graph

As Fig.2, when the student log into the system, the system will give him some questions are selected from the question database. After the student transmit his answers to system, the system will start to analyze his learning obstacles. Of course, the student's does not have much time for studying, the system hardly collect the enough data for analyzing by statistical recursive method. Because the statistical recursive has some limited: large data, the data distribution must like normal and the variants cannot too many. Consequently, the only way we can elect to adopt the gray theory to reduce the analyzing data. This matrix is called the gray relational conceptual matrix.

2 Gray relational learning obstacles analysis

The gray decision making system is meaning that the system includes some gray element (uncertainty or incomplete factor). In general case, the decision making space X is constituted by event sets S• {Sij} and efficiency sets R..

After the student interact with system, the system can collect his data to assemble the gray relationship's matrix. The analysis method explains as following.

Table 2 the relationship matrix

relation / node	Node 1	Node 2	Node 3	Node 4	Node 5
Node 1	0	0	0	0	0
Node 2	0	0	0	0	0
Node 3	0	0	0	0	0
Node 4	0	0	0	0.5	0.5
Node 5	0	0	0	0.2	0.8

Table 3 the gray relationship's matrix

relation / node	Node 1	Node 2	Node 3	Node 4	Node 5
Node 1	0	0	0	0	0
Node 2	0	0	0	0	0
Node 3	0	0	0	0	0
Node 4	0	0	0	1	1
Node 5	0	0	0	0.2/0.8	1

1. According to the Grey formulate, can translate table 2 to table 3. The system can calculate each node's average weight, and according these values to arrange their ranking.

Table 4

Node 1	Node 2	Node 3	Node 4	Node 5
0	0	0	1.25/2	2/2

2. If the nodes weight higher than the threshold value 0.3, the system can find the weight at node 4 and 5 are higher than 0.3, the system define these nodes are the learning obstacle nodes.
3. At the same time, according to the relation's matrix (table 2), the relation 4-5 is 1 higher than • •cut (0.3) is the relation of learning obstacle.
4. According to the expert's rules decide expanding or reducing the learning obstacle area.
   Use the aforementioned logic the system can reduce the relation 5-4 and relation 4-5 to infer the learning obstacle area is node 5

3 Conclusion

On the teaching the most afraid thing is to induct him learning the inert knowledge. Therefore, in all teachings methods the discovery teaching is the only one can avoid this problem that is why we adopt the discovery teaching to develop our system. But how to break through the discovery teaching' s net bottle, our issue are: integrate the concept graph and gray decision-making system to develop the gray analyzing method, and use it to discover the student' s learning obstacle. This analyzing has an ability to point out the learning obstacle area, and enhance the inferring ability to find the student' s learning obstacles or the incompletely knowledge, then pass through the expert' s rules, the crossing analysis method can find the problem kernel. Then system rely on this result to elect the problem saving content, let the student can learn it again and rebuild his knowledge structure until he can construct the whole knowledge.

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Construct in-service Training Web Site for School Teachers

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1 Introduction

Information technology grows rapidly recently. People use Internet to obtain many kinds of information. The Internet has become the most important path in cyber world. In the last five years, using the Internet to carry out distance learning, especially for teachers' in-service training, changes the style of education.

To actualize the policy which was to build an lifelong-learning education environment, Ministry of Education delegated National Kaohsiung Normal University (NKNU) to manage Asynchronous Distance Learning class for high school teachers in Oct, 1999.

2 Construct Asynchronous Distance Learning Web page

Generally speaking, teachers have to control the instructive materials, activities, learning process and evaluation. Every instruction system must include all of the three factors as following:

2.1 Instructive materials and activity designing

If we just put the materials onto web site, they look like electronic books on Internet. It is helpless for students. Therefore, when designing the contents of curriculum, we make it in "practicing" orientation. Activities make teacher and students interact with each other and avoid students to feel humdrum or like reading an electronic book.

2.2 Evaluation

When students finish learning a chapter, we give them an formative evaluation to verify whether students master the thesis or not. If students pass the formative evaluation, they can continue the curriculum. If not, they have to go back and learn it again until they pass the formative evaluation. The system would give some feedback to students, they would know which part of contents they don't understand yet. Then, we always hold an examination when finishing the curriculum, the summative evaluation. (Figure-1)

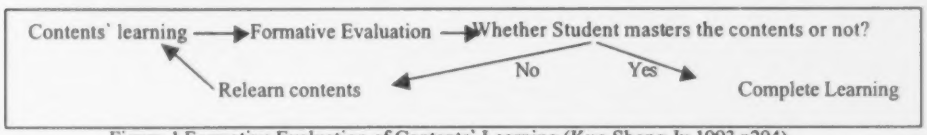

Figure-1 Formative Evaluation of Contents' Learning (Kuo Sheng-lu,1993,p294)

2.3 Learning process

Instead of quantification of examination, we should care about the reflection from students after instruction and learning. Grades cannot decide students' learning efficiency. During designing the materials, we considered every details of students' learning process. These include

- counts in connection
- counts in joining the forum
- contents what student discuss
- chatting situation between teacher and students

- Homework – students work hard or not
- Chapter evaluation (formative evaluation)
- teachers and students communicate by email

All items can be saved into database so that we can estimate student' s behavior in learning.

3 Concepts on designing curriculum

We design several activities and strategies. The activities will make students concentrate on the contents. we consider about the strategies as following:

3.1 Homework:

We assign homework after students finish learning every chapter. They can evaluate themselves through homework to know how much they learn and review contents again.

3.2 Operative Orientation:

In the homework, they have to work some operation by computer, such as computer game.

3.3 Self-determination:

Self-determination means that students have to study by themselves and plan study schedule by themselves.

3.4 Interactive :

We define interaction into two ways : one direction and two direction (Table-1).

	One direction	Two direction
Asynchronous	Announcement FAQ	On-Line Forum
Synchronous		Chat Room

One direction: teacher to student
Two direction: teacher and student

Table-1 Interactive model

3.5 User Interface

What users feel about it is very important in internet environment. Hyperlink always be mazes for a novice in the internet. Trying to solve user interface problem , we use several ways as following :

3.5.1 Frame: cut web pages into several frame to reduce confusing

3.5.2 Tree menu: from the reaction of students , the tree menu is easy to access the pages

3.5.3 Learning Path: guideline for students on the web

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Constructing a Real-Time CAD Learning System Based on OpenGL in Web-Based Environment

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The purpose of this paper is to apply network technology to make the design of Web-based learning graphics systems for user. Several issues will be addressed in this paper such as the development of an Integrated Interactive Graphics System (IIGS) for a better design environment. In this paper, we attempted to develop a web-based graphics learning system by Bézier, B-spline and NURBS algorithms. The purpose of the research was to increase the effect of Computer-Aided Design (CAD) in network .The other advantages is that network browser is the common platform in internet and intranet, the graphics system can be portable cross different operating system, as like windows 98,linux..etc. In fact, the graphics learning system have attempted to be shared the resource each other.

Keyword: **OpenGL, VRML, NURBS, CAD/CAM, CAI, Curves, Surfaces**

1 Introduction

As the Internet has improved in the last ten years, web-based graphics learning has become very important in Internet. In recent year, the distance learning by Internet has been established and developed in Computer-Assisted Instruction (CAI) system. In this paper, the user can design and learning sculpture curves and surfaces on a personal computer by the interactive way. The graphics system has friendly interface in operating process.

OpenGL is a software interface that allows the programmer to create 2D and 3D graphics images. OpenGL are both a standard API and the implementation of API. In other words, OpenGL is a set of functions which have the same syntax and which act the same way on every platform, even though different vendors have written the actual subroutines, which implemented the API standard.

Graphics programming concepts underlie the function of OpenGL. These concepts are easy for the average application programmer to understand and use. OpenGL is independent of the hardware, operating, and windowing systems in use. Using OpenGL to make a program is easier than using API to do. API is integrated into a windowing system, since learning how to program a windowing system is often quite complicated.

2 Curve Modeling

Curve methods are usually included in different courses such as geometric modeling, CAD/CAM, computer-aided geometric design (CAGD), computer graphics, etc. In teaching this material, it is essential that students have an access to computer graphics facilities. Practical experiences help them to understand the dry theory. There are many books concerning curve and surface modeling and each of them considers

this subject in a different way (with some modifications). Users are confused, especially beginners. The next weakness of method representations is in lack of comparative means. Learning can be more effective if different methods are studied simultaneously on the same data by changing control parameters.

This field is developing very quickly and therefore researchers need also an effective comparative tool for their new improved approaches or methods. For these reasons, a program package for modeling and analysis of parametric curve methods called CM ("Curves Modeling") has been constructed. It is written in OpenGL. Not only 2D but also 3D curves are considered. Three various methods are incorporated in CM in the first menu level. Including all menu levels, there are ten methods or their modifications. In the interpolation methods, a curve passes through all control points, in the approximation methods, however, a curve passes only near to control points.

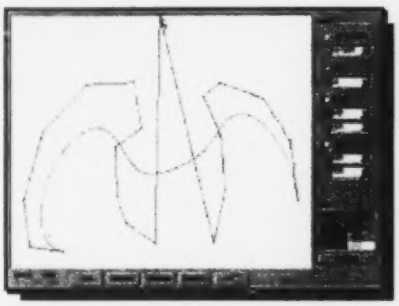

Figure 1. The Curve modeling interface

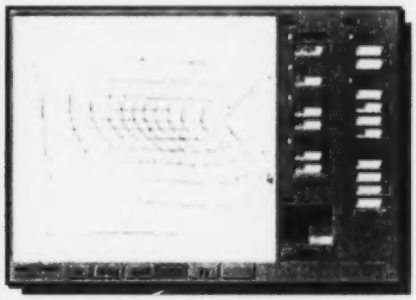

Figure 2. The Surface-modeling interface

A curve is compounded of small curves called curve segments and is determined by an equation in parametrical form (parameter u). In the knot vector for u (Uknot), there are parameter values for segment boundaries.

3 The Bézier, B-spline and NURBS Curves Algorithms.(extract)

NURBS curves:

A pth-degree NURBS curve is defined by

$$C(u)=\frac{\sum_{i=0}^{n} N_{i,p}(u)w_i P_i}{\sum_{i=0}^{n} N_{i,p}(u)w_i} \quad a \le u \le b \tag{12}$$

Where the {Pi} are the control points (forming a control polygon), the {Wi} are the weights, and the {Ni,p(u)}are the pth-degree B-spline basis functions defined on the non-periodic (and non-uniform) knot vector.

$$U=\left\{\underbrace{a,\ldots,a}_{p+1},u_{p+1},\ldots,u_{m-p-1},\underbrace{b,\ldots,b}_{p+1}\right\} \tag{13}$$

4 Surfaces Modeling

In the computer graphics, a surface is usually generated by a surface representation method on a control net (linked control points in a 3D space). Methods for surface representation are divided in two major groups: approximation and interpolation methods. At the interpolation methods, a surface passes through all control points, at the approximation methods , however, a surface passes only near to control points. A surface is compounded of small surfaces, called patches, presented by two families of isoparametric curves.

A program package for modeling and analysis of parametric surface methods called SM ("Surfaces

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Modeling") has been constructed .A surface is determined by an equation in parametrical form (parameters u and v). We speak about u and v directions (parametrical view) or about direction X and direction Y respectively (2D screen view). In the knot vectors for u and v (Uknot, Vknot), there are parameter values u and v for patch boundaries.

5 The Bézier, B-spline and NURBS Surfaces Algorithms.(extract)

NURBS surfaces:

A NURBS surface of degree p in the u direction and degree q in the v direction is a bivariate vector-valued piecewise rational function of the form

$$S(u,v)=\frac{\sum_{i=0}^{n}\sum_{j=0}^{m}N_{i,p}(u)N_{j,q}(v)w_{i,j}p_{i,j}}{\sum_{i=0}^{n}\sum_{j=0}^{m}N_{i,p}(u)N_{j,q}(v)w_{i,j}} \quad 0\le u,v\le 1 \tag{14}$$

The $\{P_{i,j}\}$ from a bi-directional control net ,the $\{W_{i,j}\}$ are the weights ,and the $\{N_{i,p}(u)\}$ and $\{N_{j,q}(v)\}$ are the non-rational B-spline basis functions defined on the knot vectors

6 The structure of the graphics learning system:

(1)System operating process and interface:
(2) Graphics algorithms:

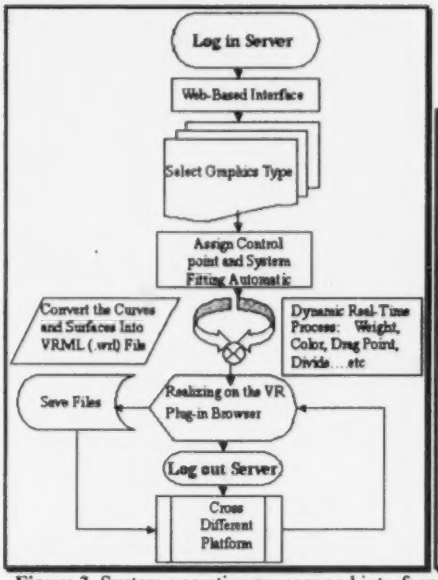
Log in Server
Web-Based Interface
Select Graphics Type
Assign Control point and System Fitting Automatic
Convert the Curves and Surfaces Into VRML (.wrl) File
Dynamic Real-Time Process: Weight, Color, Drag Point, Divide....etc
Save Files
Realizing on the VR Plug-in Browser
Log out Server
Cross Different Platform

Figure 3. System operating process and interface.

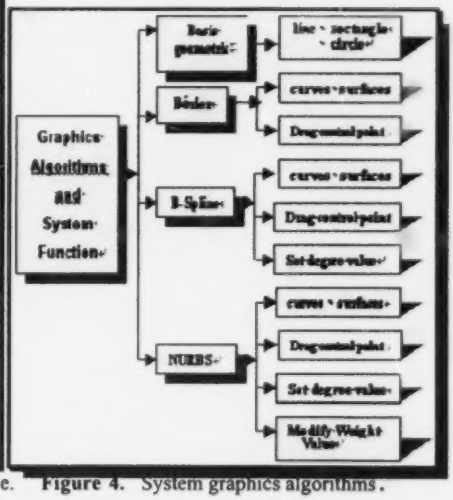

Figure 4. System graphics algorithms.

7 Brief Overview of OpenGL

OpenGL is the premier environment for developing portable, interactive 2D and 3D graphics applications. OpenGL have the following obvious benefits:

(1) Reliable and portable
(2) Scalable

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(3) Easy to use

VR as a Training Tool

Virtual Reality training can dramatically reduce the cost of delivering training by decreasing learning time for student and instructors.

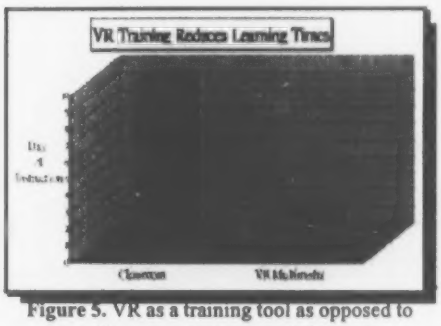

Figure 5. VR as a training tool as opposed to Classroom techniques (RTI)

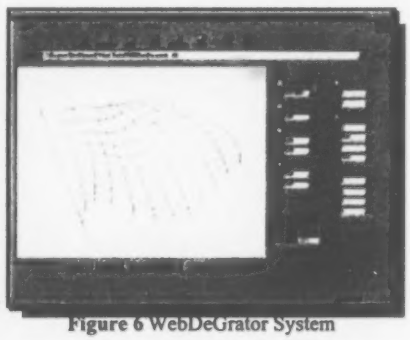

Figure 6 WebDeGrator System

8 Implementation and Example:

(1)The Integrated graphics Learning real-time system:
(2)Drawing NURBS curves and Covert Curves into VRML 3D Type:

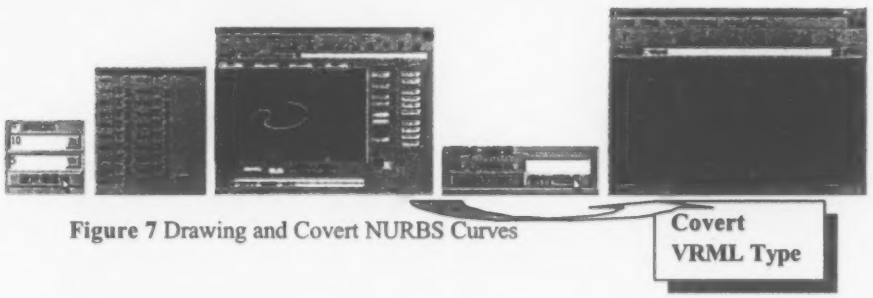

Figure 7 Drawing and Covert NURBS Curves

9 Experiment results:

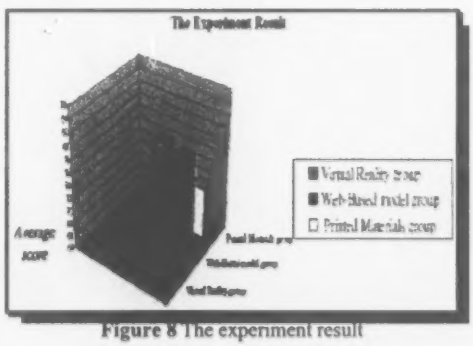

Figure 8 The experiment result

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While the differences between the groups were significantly different, the virtual reality group performed is best; the Web-based model group is better than the printed materials group.

10 Conclusion:

The paper describes a new technology that we have established a VR-Based real-time graphics system. In summary, the system offers the following contributions:

1. To accomplish an Integrated Graphics Learning Real-time System
2. To share the resources in network.
3. To establish a computer network assisted learning system.
4. To explore and compare these algorithms of the sculpture curves and surfaces.
5. To integrate VRML with web–based learning system and realize 3D graphics on VR environment

11 Acknowledgments:

We would like to thank the anonymous reviewers for their invaluable and constructive comments that help to improve this paper. This research is working by the Automatic & CAD laboratory under Department of Electrical Engineering National Central University, Taiwan.

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3 Design Issues

3.1 Screen design

Interactive media places users in a one-on-one relationship with a program that can be as intimate, or more intimate than, a face-to-face exchange [22]. For that reason, it is the task of educational multimedia producers to transform that relationship into a successful learning experience. In a user-controlled environment that enables students to turn off the program whenever they want, screen design becomes essential to maintaining learner motivation. Effective screen design allows for maximum learning from the materials while providing the learner with appropriate control of the learning process [16]. This could be compared to the teacher's role at the beginning of a traditional classroom setting. An effective screen design sets the stage for meaningful 'deep learning' to take place and motivates the student to stay engaged. The signs of a poorly designed screen are cluttered displays, complex and tedious procedures, inadequate command languages, inconsistent sequences of action and insufficient informative feedback [20]. Such designs can lead to anxiety, poor performance and dissatisfaction with the program. Some researchers recommend limiting the amount of text on screen to three lines in order to prevent information overload [4]. Users are most effectively able to concentrate on the multimedia material when the screen is made user-friendly with consistent commands and positioning of buttons. The importance of the screen design is corroborated by a number of researchers [21], [1]; [23]; [8].

The choices for screen design are endless, but the two basic extremes are simple and complex. There are both advantages and disadvantages for either consideration. The primary advantage of keeping the screen 'simple and uncluttered' is that it is less likely that users will suffer from immediate sensory 'overload.' As Stemler points out, multimedia instruction packages can become "nightmares when designers try to dump anything and everything into a single program simply because the capability is there" [21]. Most researchers agree with this approach [17]; [18]; [19].

In many cases, a thoughtfully designed complex interface will hold the user's attention longer. The use of a metaphor is one way of integrating a number of complex features with a simple visual structure and provides users with a sense of place, familiarity and ease of use. Within VLU, the metaphor of campus buildings is employed to distinguish between the four sections of the program: Grammar, Listening, Vocabulary and Writing. This metaphor is also useful for selection of the three levels of difficulty within the program. After diagnosis, the users take an elevator to the appropriate level of the unit they are working in.

3.2 Navigation

Unlike passive approaches to education, in student-centered learning, users navigate the path of their own learning. Because of this, the navigation design of a program determines the level of interactivity users will experience. There is a delicate balance between giving enough sense of direction to avoid anxiety, without over-directing users. It is important for users to always know where they are going. Too much freedom may result in students reviewing material or completing tasks that are not relevant to their purpose. According to the findings of Laurillard, learners working on interactive media lacking a clear narrative structure will display learning behavior that is generally unfocused and inconclusive. Learner control, one of the key benefits of interactive media, thus becomes pedagogically disadvantageous if it results in mere absence of structure [14]. While the users should be provided with sufficient choice through hypermedia links, there needs to be a balance between jumping around and sticking to one task [5]. According to Wild and Quinn, the ideal combination is "scaffolded reflection", that is, navigation that encourages thinking without losing the focus of the instruction [24].

There are several possibilities for how users access materials: sequentially, semi-directed, free choice or through pathways. Each of these methods can be designed to have extreme linear order or extreme non-linear order where users have little or no chance of deviating from a predetermined sequence. Thus,

package possibilities can range from strict, prescribed, sequential learning to complete freedom of choice. An alternative is a semi-directed program, allowing for the possibility of choice within certain situations.

Users can be given the option of skipping ahead only when a task is finished or they can be allowed to skip ahead at any time. Common procedure is to have the exit function or menu function available to users at all times. This implies that the navigation has minimal travelling; that is, express pathways so users arrive at their desired destination as fast as possible with little or no redundancy. In contrast, users may not be given the option of skipping at all but can only exit when a particular task/topic/section/unit is finished. Kristof & Satran suggest that users should not have multiple paths to any particular location because this causes confusion [11].

In VLU, users can chose to skip ahead to sub-topics at any time, yet are required to select the Main Menu to do so. Thus, while students can jump around to any building or level, they automatically enter a linear sequence once they have chosen a particular lesson (unless they click on the Main Menu, which is available at all times). This is particularly true for the Grammar section, where skipping ahead may mean missing important grammatical rules and explanations. In this section, students choosing to skip ahead will hear a friendly reminder from the animated host: "You are not advised to go to this task at this stage". Users are then given the option of proceeding anyway, or returning to the previous section.

3.3 User Feedback

Within the interactive format, the educational value of a program is directly linked to the style and quality of user feedback. The users can receive either immediate or delayed feedback to responses or actions. Immediate feedback lets the users have only one attempt at providing correct information, or making a decision. Delayed feedback, in contrast, allows the users to have a longer learning experience, an experience which requires completion of one or more steps before the users receive any feedback.

Feedback can also range from: i) individualized feedback which is based upon individual choice and performance, ii) to a more general response which addresses content considerations, iii) to a type of scoring (percentage, grade, written comments). Personal feedback can be created to address users by name and either make suggestions or critique decisions made. In VLU, the computer greets users by name as they enter the program. Because most users tend to respond positively to being addressed individually, this is usually seen as a positive option [9].

3.4 Testing

Users can also be tested before, during, or after using a package. The test that precedes the work done in the package can be used as a diagnostic tool for the user. By diagnosing weaknesses or strengths, students can be directed to enter the program at an appropriate level of difficulty. Considerations on the nature of the test include whether or not the test should be timed, whether students should be able to choose the subject matter of the test and how long the test should be. The answer to these questions will depend upon the type of material being tested. Analytic material probably requires no time limit, whereas non-analytic material may need to be timed. A secondary consideration would be how many times a user can take a specific test. How often should tests in general be given? Once per unit? One test per section or per topic?

If testing is used, diagnosis will be more reliable if several tests have been taken; therefore, a bank of tests is useful. It follows then that each test must accurately assess the skills being tested and all tests must be equal in difficulty. The generation of tests can be accomplished by having a single bank of questions with the computer randomly selecting the questions. This will ensure that users do not duplicate test materials.

Testing within VLU is an option provided to users once they have entered one of the campus buildings. The test length varies according to each section, but averages about 15 minutes per unit. For example, upon entering the Listening Test area, users are presented with a pop-up menu that asks them to select a test in

their area of interest: Environment, English, Politics and Business or Social Issues. In this way, students are able to control their learning experience and are not penalized for a lack of knowledge in a particular area.

3.5 Scoring

Another question designers will need to address is what kind of report users will receive after completing a test or set of tasks. Does the program require written comments, percentage grades, or is a simple pass/fail more appropriate? Reporting can be automatic after each task, or the report can be accessed upon request. One extreme is for there to be no access to scores until the entire unit/section/package is completed; the other is for automatic reporting to occur whenever a task is completed. The feedback or report can be a numerical or graphic representation. There can be results posted on the screen, or they can be printed, or even saved to a disk. Another design possibility is to have a progress report after users have used the program for a specified period of time. The progress report can incorporate individual feedback or re-direction to an easier or more difficult level. Teachers may also want to have a network reporting option that automatically sends them the students' reports [9].

Within VLU, users are provided with a percentage grade for each task as well as an overall grade for the section completed. This provides users with a clear indication of their areas of weakness, whether it be in specific grammatical structures, writing topic sentences, listening for key words or creating compound nouns. A rating of "good", "average" or "poor" is also given, with 80 percent or higher being good, 79 to 50 as average and below 49 as poor. With this method of reporting, users are oriented within the tri-level system of the program and provided with goals for motivating improvement.

Conclusions

As multimedia producers, our goal is to harness the power of emerging technologies to achieve our educational objectives. With proper planning and design implementation, producers can not only simulate the classroom setting, but enhance it - and thus contribute to an overall rise in the level of educational standards. As Kozma points out, our ability to take full advantage of new technologies depends on the creativity of designers and our understanding of the relationship between these capabilities and learning [10]. This becomes especially important as computer-based multimedia becomes a ubiquitous aspect to learning at all levels [12]; [2]; [7].

This paper has discussed some of the issues involved in designing interactive courseware, with an emphasis on the Higher Education environment. The authors have attempted to use the experience of VLU to identify some of the key challenges involved in the various stages of multimedia design: development environment, design, user feedback and piloting. One of the greatest challenges involved in multimedia design is integrating the freedom-of-choice that makes interactivity what it is, without straying too far away from the sensible guidance necessary for any valuable educational endeavor. Designers are being challenged to create a learning environment that combines learner controlled browsing within a system-encouraged structure. As demonstrated in VLU, this bipolar dynamic is evident in almost every stage of the production process - from navigation to taskwriting to the integration of audio and visual effects. Every interactive learning production has its own set of problems and challenges, which is perhaps what makes multimedia design such an exciting and creative field to be working in. The lessons gained from VLU will continue to improve the program as it is exposed to more users and teachers, and as the development team generate new ideas for a revised version. It is hoped that these insights will contribute to the growing source of knowledge on multimedia design and ultimately lead to better products for students.

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Developing an IT-immersion Environment to Enhance Learning and Teaching in Design and Technology

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Design and Technology (D&T) as a school subject aims to provide learning opportunities for students to develop the technological awareness, literacy, capability and lifelong learning patterns that they need to live and work effectively in an ever changing technological society. Information Technology (IT) is quickly transforming education by breaking down the traditional boundaries of learning and teaching. This article discusses the ways that IT can be made relevant to the learning and teaching of D&T and in teacher education. It then describes the development of an ongoing project[#] which aims at developing an IT-immersion environment to enhance learning and teaching of D&T at a teacher education institution in Hong Kong. The setting up of this information-rich, collaborative learning environment is to complement "traditional" lab-based approach to learning and teaching of Computer Aided Design (CAD) and Computer Aided Manufacture (CAM).

Keywords: **IT-immersion, Learning Environment, Design and Technology, Teacher Education**

1 Introduction

Design and Technology (D&T) as a school subject "aims to provide learning opportunities for students to develop the technological awareness, literacy, capability and lifelong learning patterns that they need to live and work effectively in an ever changing technological society." [3] Information Technology (IT) is quickly transforming education by breaking down the traditional boundaries of learning and teaching. [5] IT is also being regarded as an effective tool for learning and teaching D&T in two main areas, namely:

- ***IT as a tool.*** IT can support many aspects of designing and making in D&T. For example, information processing and presentation, modelling, computer-aided design and manufacturing, control and communication.
- ***IT as a source of knowledge.*** Here, IT is being regarded as a source of knowledge to learn about materials, equipment, designing and manufacturing. This encompasses CD-ROM information systems, and the use of local or online databases accessible over the Internet. [2] [6]

2 IT in Education Policy in Hong Kong

The Hong Kong Special Administrative Region (HKSAR) Government launched its IT in Education Policy in 1998. [1] [5] According to this policy, Hong Kong teachers will be required to reach different levels of IT Competency in Education over the next few years; and IT-supported instruction will become one of the essential instructional strategies in future. Consequently, teacher education institutions in Hong Kong will be

[#] The project entitled "Development of an IT-immersion Environment to Enhance the Teaching and Learning of Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM)" is supported by the Teaching Development Grant (TDG) administrated by the HKIEd, which is granted by the University Grants Committee (UGC), Hong Kong.

required to integrate in their pre-service programmes IT competency elements such as producing courseware, applying the skills of computer-aided instruction, and using various electronic networks for peer support and collaborative learning.

3 The Project

The following sections describes an ongoing project which aims at developing an IT-immersion environment to enhance learning and teaching in D&T at the Hong Kong Institute of Education (HKIEd), the major provider of D&T teacher education in the territory. This project is a response to the HKSAR Government's urge for the integration of IT to enhance the effectiveness of learning and teaching in teacher education institutions. [1][5] The initial target group of the project is student teachers undertaking D&T at the Institute. This target group will continually widen and might eventually include practising teachers in D&T and other technology-related subjects in Hong Kong secondary schools.
The project aims to:

- develop an IT-immersion learning environment for student teachers majoring in D&T, especially focused on areas of CAD and CAM;
- develop appropriate courseware for the enhancement of learning and teaching of basic and selected topics on CAD and CAM;
- develop an appropriate web-interface for students and staff to enhance face-to-face classroom interactions;
- enable students to appreciate modern techniques of product design and prototype making through the use of CAD and CAM technologies.

4 IT-immersion Learning Environment for D&T

Davies [4] suggests that an ideal learning environment for D&T is one where the learners have maximum autonomy and are working on self-directed projects and teachers are constantly assessing with pupils where they are and where they need to go. The IT-immersion learning environment under discussion utilises some of the attributes and resources of Web-based learning and adopts a constructivist approach to create a meaningful learning environment where learning is fostered and supported. This IT-immersion environment, we believe, would facilitates greater interaction between the teacher and students, and students and students; assist D&T student teachers transit to the new mode of learning and teaching, and enable them to develop habits of life-long learning. To effect the paradigm shift from a largely teacher-centred approach to a more interactive and learner-centred approach, it is important that D&T student teachers appreciate the need for the change and are receptive to the challenge of taking up their new role as a learning facilitator in future.

Key features of the IT-immersion environment include:

- ***Learner-centred, time and space independent learning***. With the use of Web-based instructional materials, students are allowed to progress at their own pace and at any time and space.
- ***Changing Roles of Teachers and Students***. In the IT-immersion environment, the role of the teacher changes from knowledge provider to that of facilitator and guide. Conversely, students are no longer passive learners. They become participants, collaborators in the creation of knowledge and meaning.
- ***Self-directed Learning***. One increasingly important competency in the future society will be "self-directed learning". In the IT-immersion environment, students continually learn to use IT tools for the accessing, processing, and transformation of information into new knowledge.
- ***Just-in-time Learning***. "Just-in-time learning" [7] implies a high level of individualisation and self-direction in the learning process. Each student learns just what he/she needs at the time when he/she needs it. This is a radical diversion in the instructional delivery system from place-based and time-fixed group instruction to one that is fully under learner-control.
- ***Individual differences accommodated***. Learning is a complex process that takes place as an interaction between learners and their environment. The interactive multimedia and hypermedia capabilities of Web-based and CD-ROM based instructional materials would enable student control over timing and pacing and provide interactivity and active learning.
- ***Collaborative / Cooperative Learning***. Collaborative learning in this IT-immersion environment regards that both teachers and students be active participants in the learning process. The Web, for

instance, presents an especially good environment for asynchronous collaboration in which students work together but not necessarily at the same time. This IT-rich environment also provides ground for cooperative learning that students and teachers interact together in order to accomplish a specific goal or develop an end product which is content specific. For instance, an ad-hoc group of students, teachers, and perhaps outside experts, can come together for a particular task or design project. The group splits into distributed design teams to tackle design challenges. The design teams interact over the computer network, working cooperatively and drawing on different expertise. The design is shared over the network, evaluated, and combined into an integrated artefact or system.

It is perhaps worthwhile pointing out that in an IT-immersion learning environment, IT is still considered as a supportive tool. Its introduction supplements, and indeed may change the "traditional" learning and teaching approaches in D&T. However, it is not intended to and will not replace traditional teaching altogether. For one reason, D&T is intrinsically an action-based subject. Engagement with designing and making requires students to be active cognitively and physically. Besides, lab-based activities serve a variety of different purposes that would be unlikely replaced by other means [8], for example: (a) first hand experience of using a variety of materials, equipment and processes safely; (b) actually realise high quality products, test them and evaluate them in use; and (c) face-to-face interaction among peers and the tutor.

5 Basic Components

The IT-immersion environment comprises two major components, namely: (a) the physical component, and (b) the virtual component (Figure 1).

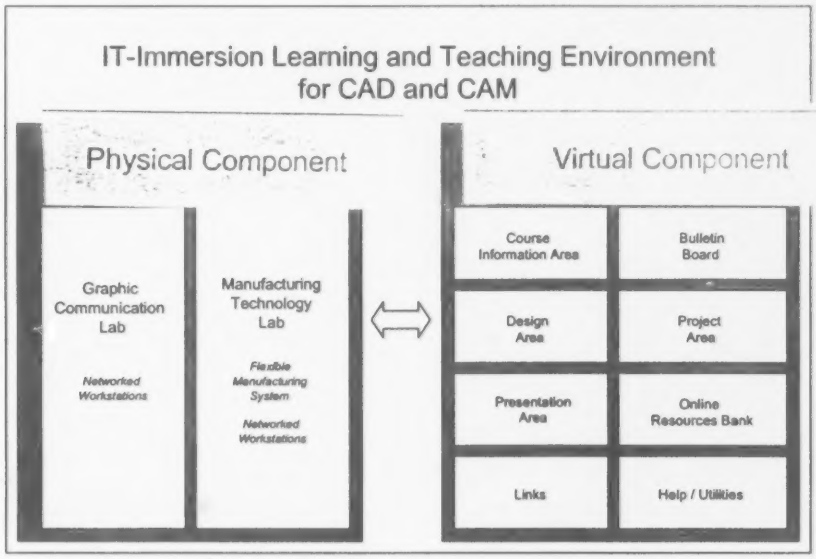

Figure 1. Major Components in the IT-immersion Learning and Teaching Environment.

The ***Physical Component*** includes facilities installed in the two labs at the HKIEd for CAD and CAM:

- ***Manufacturing Technology Lab***: A Flexible Manufacturing System (CNC Lathe, CNC Mill, and Robot), a CNC micro-router, 15 networked PC workstations, video-conferencing systems, appropriate software and peripherals, etc.
- ***Graphic Communication Lab***: 21 networked PC workstations, video-conferencing systems, digital camera, appropriate software and peripherals, etc.

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The ***Virtual Component*** of the IT-immersion environment include:

- ***Course Information Area*** - for students to gain access to course-specific information such as course outlines, schedules, course materials, assignments and other course-related information.
- ***Bulletin Board*** - for teachers and students to post up announcements.
- ***Design Area*** - for supporting both synchronous communication (e.g. real-time interactive chat, used to brainstorm with teachers or peers) and asynchronous communication (e.g. e-mails) to facilitate design activities. For example, students can "talk" online and discuss their design ideas via video-conferencing and/or Internet technologies with peers, teachers or experts outside the campus who can provide them with suggestion for improvement on the design. Digital cameras can be used to record the development of models/products and to present design ideas.
- ***Project Area*** that houses students' individual and collaborative design projects. A Data Bank will be set up for students to store their design works. The Data Bank will become a central design database, accessible by all members of each of the design and manufacturing teams to ensure that all team members are working with identical information.
- ***Presentation Area*** - for students to present their projects and showcase their design work beyond the classroom and to a wider audience.
- ***Online Resource Bank*** - for teachers to upload and retrieve interactive instructional and reference materials.
- ***Internet links*** - to support teachers and students using the Internet to locate professional materials and content resources in D&T and other related disciplines.
- ***Help / Utilities.***

6 IT-enhanced Activities and Learning Experiences

In the IT-immersion environment, student teachers are provided with the opportunities to use IT to explore, develop, model, communicate and realise their design ideas in a variety of ways. As such, IT becomes an integrated and natural part of their study in D&T. More specifically, to take as an example, video conferencing technology can be used as an effective medium for developing new ways of learning and teaching D&T and introducing teachers and students to various aspects of information, communications and design technologies. Using the latest information and communications technology provides the opportunity for expertise and resources to be made available to pre-service and practising D&T teachers off-campus from the HKIEd. Via video conferencing systems or the Internet, they can work collaboratively together on concurrent design projects, discuss problems and jointly solve them, and exchange ideas and information.

In brief, working in an IT-immersion environment would help D&T student teachers to understand how to become discerning users of available hardware and software. This in turn, would help them to understand what IT can and will do to enhance their future pupils' learning in D&T.

7 Conclusion

This paper discussed the potential of an IT-immersion approach to provide D&T student teachers with a richer, more meaningful education relevant for the future workplace and learning environments. It is also suggested that this IT-immersion approach can be used in a mixed-mode manner to support traditional lab-based approach to learning and teaching CAD and CAM. This adjunct or mixed-mode seems appropriate for a wide range of learning and teaching activities in D&T where real world experience and face-to-face interaction are essential. By using a mixture of traditional and IT-immersion instructional methods and tools, the learner can experience recent technology development and its impacts on learning. The point is to find out the right balance.

The project is still at its developmental stage, the effectiveness of the IT-immersion approach to learning and teaching D&T has yet to stand the test of time. However, the experience so far suggests that the project will be a success and will bring substantial benefits to both teaching staff and students.

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Development of Cross-Cultural Communication System and Web-based Japanese Education

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In 1998 we presented a framework and system construction of "Images of Japan," a learning system of the Japanese culture and language in Beijing, China. In this paper, we discuss the results of our initial evaluation of its framework and system based on personal feedback from students and on the responses to the survey carried out in the form of questionnaires. Even though the overall assessment was positive, we have received a few suggestions for improvement. We are now working on the implementation of improvements, some of which we also introduce here.

Keywords: **Cross-Cultural Communication, Japanese Education, Communication Tool**

1 Introduction

"Images of Japan" was constructed to develop an effective network-based learning environment of cross-cultural communication: disseminating information on Japanese culture and providing opportunities to learn Japanese. In order to encourage active participation and to keep the users motivated to share their knowledge and develop a deeper understanding which they could not achieve alone, we have had Japanese students and non-Japanese students select items which they want to introduce or they want to know. More than 300 items have been collected. The data also reveal that there is a wide gap in their perception of Japanese culture, particularly between Japanese and non-Japanese students. We expected that this perceptional gap between the Japanese and foreign students would serve to facilitate cooperative and collaborative learning and sharing of knowledge among the users and to lead to their active participation in the program.

2 The Framework of the System and its Evaluation

Users can jump from the top page to any pages by clicking the icons installed in the index. Since this courseware is primarily constructed to show the diversity of Japanese society and to encourage Japanese and non-Japanese students to think about Japanese culture and to share opinions and ideas with each other, the pages of Classification and Collaboration are the central parts of this framework. Over 300 cultural items are presented in the Classification page. In the Collaboration page, "Bulletin Board," "E-mail," and "Voting," devices are installed. The "Bulletin Board" serves not only to link together Japanese students and non-Japanese students giving them opportunities to chat or exchange information, but also to provide data to evaluate the effectiveness of this collaborative learning program. .

In the "Voting" users are encouraged to vote for the items in which they are interested. Users can also add new items of their own choice in the existing page. The ranking is continuously updated so that users can feel a sense of participation and maintain their interest. In addition to "Bulletin Board" and "Voting,"

"Questionnaire Page" was later added to obtain direct opinions from the users and to evaluate how much collaboration and development of knowledge has been achieved. The Questionnaire basically consists of multiple-choice questions. As evaluation based on these means should be carried out through a long span of time, however, we have decided to perform an experimental assessment in the form of a questionnaire in the meantime. The number of responses collected was 63 in total (51 Japanese and 12 non-Japanese students.) Questions focus on the following themes; (1) the overall framework, (2) information on the Japanese cultural items, and (3) the Japanese language learning program.

3 Results of the Questionnaire on the Overall Framework

In the evaluation of the overall framework, the following issues were addressed. The responses turned out basically positive.

Table.1

	Good	bad
Accessibility of items	78%	22%
Layout	92%	8%
Linking	98%	2%

Table.2

	very good	good	not good	bad
Size of the letter and presentation	12%	80%	6%	2%
Screen presentation	12%	80%	8%	0%
Control of Screen	8%	80%	10%	2%

Table.3

	Very interesting	Interesting	Not interesting
Photo picture	8%	78%	16%
Illustration	14%	53%	33%
Animation	20%	68%	12%

With regard to question of "Accessibility of items," however, 22% of the students responded negatively. The reasons could be multifold. The list of cultural items could be too numerous for participants to screen them thoroughly. The instructions on how to use the page might have been inadequate. A few students might not be able to plug in the page. Also, a minor technical problem might be present. However, the quantity of photos, illustrations, animations and sound is controlled so that users will not find them overwhelming. In any case, improving the accessibility is one of the issues that requires further study. On the other hand, we feel that the number and wide variety of cultural items, which might look overwhelming to some viewers, is in fact an important advantage. At the moment each one of those items is categorized into sixteen major subjects, and the users have to select one of the major subject first to reach the page of each item. How to arrange topics so that the users will find them easy to access is an issue to be studied as well.

4 Japanese Cultural Items

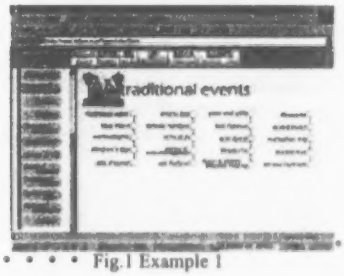

Fig.1 Example 1

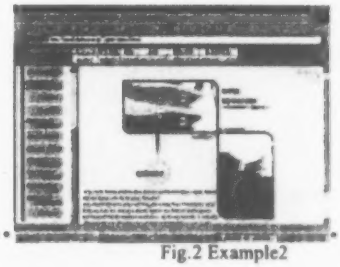

Fig.2 Example2

The above are examples of a cultural page. Each item basically consists of two pieces of visual information either in the form of photos , illustrations or animations, followed by the comments or brief information given by the students who participated in the original survey are given. In the survey, the following four questions were asked. As shown in the figures, their responses turned out less positive than those on the "Overall Framework".

(1) Could you understand the ways young students grasp Japanese culture?

Japanese students	Yes 76%	No 24%
Non-Japanese students	Yes 100%	No 0%

(2) What do you think of this home page on Japanese culture introduced by students?

Japanese students	Useful 55%	Not useful	6%	Interesting	31%	No Answer	8%
Non-Japanese students	Useful75%	Not useful	0%	Interesting	25%	No answer	0%

(3) After having read these pages, have your ideas towards Japanese culture changed?

Japanese students	Yes 37%	No 63%
Non-Japanese students	Yes 100%	No 0%

(4) Do you want to exchange your ideas with others on the "Bulletin Board?"

Japanese students	Yes 71%	No 29%
Non-Japanese students	Yes 100%	No 0%

The reason for the negative response is in part due to lack of sufficient information on each item. Particularly, the responses from Japanese students are much less positive than those from foreign students. On the other hand, written responses from foreign students were quite favorable: saying, e.g.,

"This is a fascinating resource to learn more about Japanese culture," "I think the items introduced here are very thorough, everything from traditional to modern culture." This wide difference in the response between Japanese and non-Japanese students is basically due to the fact that those non-Japanese students are the ones who are already interested in Japanese culture and willing to learn more, while most of the Japanese students are not necessarily interested in Japanese culture, or the items presented here are not enticing but too familiar to them. The objective reasons for the negative reactions should be sought for, too. It is also evident that we have to improve the Japanese Cultural Page so as to encourage students to share their knowledge and opinions actively and enhance their cross-cultural communication skills.

5 Improvements

In order to ensure that students will use our program as a source of information about Japanese culture and as a tool for cross-cultural communication, we have to make it more attractive for them. As a first step, we are now working on a construction of a "Discussion Room.," where two groups of students, Japanese and non-Japanese, exchange their ideas, feelings, and opinions on a series of scenes excerpted from Japanese movies (one is "Funeral" and the other is "Shall We Dance?") These two movies not only reflect ways of thinking of Japanese people but also its conventions of daily life and will serve as an interesting source of cross-cultural communication. Another group of students is assigned to discuss "Bushidoo vis-a-vis Knighthood," and the fourth group of students should discuss a topic of their own choice. We expect that through these activities the students will experience both satisfaction and frustration in communicating with other people of different cultural backgrounds. The conversations recorded in the Discussion Room are being accumulated and will be analyzed as a source of studying cross cultural communication.

As for the Japanese Language Program, we could not obtain sufficient feedback from the foreign students The language program was made for intermediate students. However, since the number of foreign students who have reached intermediate level Japanese in this first experimental evaluation was limited, we could not obtain concrete comments or reactions on the program. At the time when we constructed the language program, we could not provide appropriate audio information nor video due to the problem of network speed. Since this problem has been solved, however, we are now not only adding sound to the original program but also constructing a new listening comprehension page. The listening comprehension is geared to basic level students. By doing so, a more active use of this program will be expected. It will be also used in class starting this October and the feedback from the students will be duly analyzed and be used for further improvements.

6 Future Plans

The results of the initial experimental evaluation have suggested that this home page could be a good source of information on Japanese culture. However, they also have revealed that some changes in the framework as well as in the content of the cultural and language pages should be made in the near future. Some of those changes are now being made as mentioned above. The program also needs to expand to include the participation of other universities, particularly those which they have a Japanese language program or course on Japanese culture. After implementing further improvements and having obtained a sufficient number of responses, we will reevaluate the home page.

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DIYexamer: A Web-based Multi-Server Testing System with Dynamic Test Item Acquisition and Discriminability Assessment

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With the rapid growth of both computer technology and the Internet, conventional models of testing are gradually being replaced by CAT (Computer Assisted Testing) systems. However, the major problem in most CAT systems is the difficulty in refreshing and supplying test items. This paper presents a novel network CAT system, DIYexamer (Do-It-Yourself Examer). It has three features that differentiate it from existing CAT systems: student DIY items, item-bank sharing, and automatic assessment of item discriminability. DIYexamer accepts test items contributed form teachers as well as students, and allows limited item sharing between item-banks possibly maintained by different organizations. An algorithm is applied dynamically to assess the discriminability of items in item-banks in order to filter out less qualified contributions, hereby assuring the quality of stored items while scaling up the size of item-banks.

Keywords: **computer assisted testing, test evaluation, test acquisition, discriminability, distant learning**

1 Intorduction

With the continuing development of computer technology and the Internet, educators now have new alternatives for creating, storing, accessing, distributing and sharing learning as well as testing materials. Should testing be performed on or learned from computers, and then a computer can best assess the work, Bugbee (1996)[1]. Hence, assessing the learning achievements and attitudes of students via computers or networks becomes a challenging task for many educators and researchers.

A. Computer-assisted Testing Categories

Computer-assisted Testing (CAT) or Computer-based Testing (CBT), the use of computers for testing purposes, has a history spanning more than twenty years. The documented advantages of computer administered testing include reductions of testing time, an increase in test security, provision of instant scoring, and an individualized adaptive testing environment [2][3][4][5]. As listed in Table 1, three categories of CAT are currently employed: standalone packages, test centers and networked systems.

TABLE 1: Categories of CAT

	Network support	Item generator	Random item selection	Item source	Item quality assessment	Item-bank sharing	Test result analysis
Standalone package	No	Built in item-bank	Yes	Fixed	No	No	Yes
Test center	Yes	Expert	Yes	Limited	Yes	No	Yes
Networked system	Yes	Built in item-bank	Yes	Fixed	No	No	Yes

1) Standalone package: This type of computer software package is typically stored on disks or CD-ROMs. Some packages have built-in item-banks, while others require teachers to input test items. These CAT packages generally do not have network capabilities.
2) Test center: The test centers or lab services require dedicated computer terminals for testing purposes. Students are required to complete the computer-based tests at the centers. Well-known applications of this type of service are Graduate Record Examinations (GRE) and Graduate Management Admission Test (GMAT), as provided by Educational Testing Services (ETS) [6].
3) Networked system: This enables students to perform an examination through an Internet connection. Concurrent testing of multiple users, automatic score calculation, and automatic test result analysis are supported by a networked system. The major advantages of networked systems are the convenience of examinations and test result calculation. However, the major flaws are the limitation of the amount of items and no item discriminability assessment.

B. Problem Statement

Regardless of which CAT system is employed, a critical issue in developing CAT is the construction of a test item-bank. Traditionally, asking teachers and content experts to submit items generates the item-bank. Three major drawbacks of the traditional method can be observed:
1) Limitation of item amount: Teachers and content experts tend to have similar views on the test subject. That is, in a given field vital subject matter might be confined. Therefore, although more teachers and content experts are invited to contribute test items, the total number of distinct items remains low.
2) Passive learning attitude: Students are conventionally excluded from the creation of tests. In a typical computer-assisted testing system, teachers generate tests, the system presents test sheets and students then complete the tests. That is, within the system of testing, they play a passive role, and are not afforded the opportunity to conduct "meta-learning" or "meta-analysis."
3) No guarantee on item quality: Permitting students to generate tests may be a possible solution to the aforementioned problems. However, this raises a new problem: quality assurance and ensuring that the tests are worth storing and used for further tests. Even when the whole item-bank is contributed by teachers and content experts, ways to dynamically assess and filter test items are needed.

The rest of this paper is organized as follows. The three distinct features of DIYexamer are introduced in section 2. Section 3 describes how the DIYexamer was implemented and its functionalities for administrators, teachers, and students. The discriminability calculation formula is then presented in section 4. Finally, the accuracy of discriminability discretion of DIYexamer and conventional methodology are compared through a real-life test in section 5.

2 The Diyexamer Solution

The DIYexamer[7] is a Web-based multi-server system that allows students to contribute test items, and provides an effective means of verifying the discriminability of these items. Three main ideas are as below:

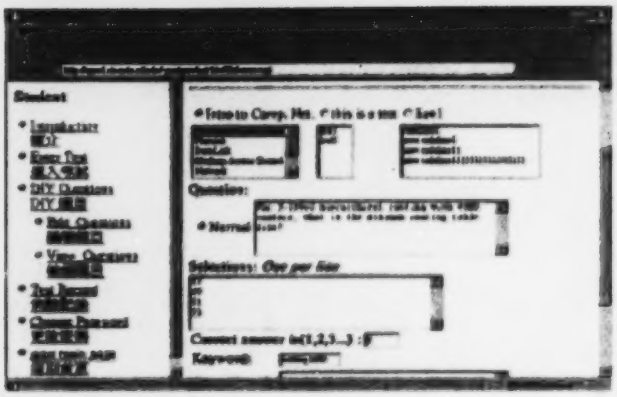

Fig 1: Students generate items into the item-bank

1) Item DIY by students: DIYexamer allows students to generate test items into the item-banks online as Fig 1. Teachers can query these items generated by students as Fig 2. In addition to rapidly increasing the total number of items in an item-bank, this feature also encourages students to develop *meta-learning*, i.e. *creative learning*. In order to submit tests, students must thoroughly study the learning materials, develop higher-level overviews of the materials, and practice cognitive and creative thinking.

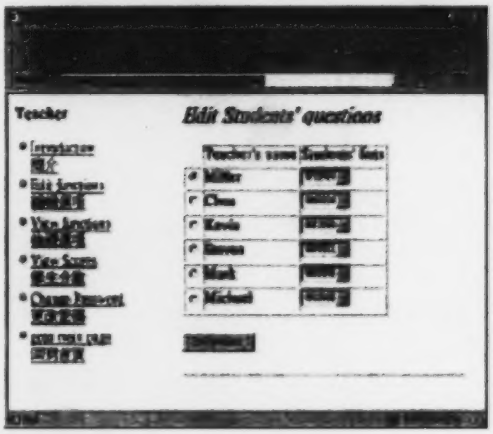

Fig 2: Student DIY items as queried by teachers

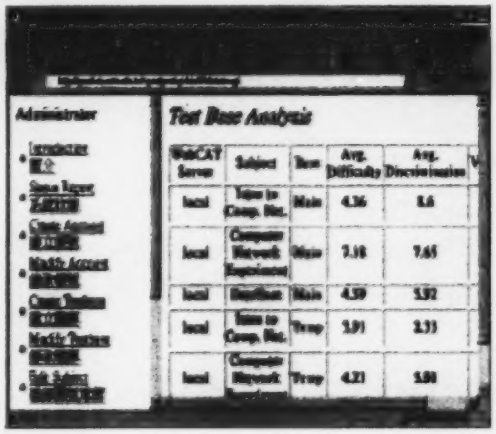

Fig 3: Average item discriminabilities of item-banks

2) Assessment of item discriminability: DIYexamer provides an item-discriminability assessment method to ensure the quality of the stored items. In addition to ensuring the internal consistency of existing test items, this method also continuously and dynamically screens additional new items in the item-bank. Fig 3 shows the average item discriminabilities of several item-banks.
3) Item-bank sharing: DIYexamer, a scalable multi-server system, connects many item-banks stored in different servers. Therefore, via the Internet, more items can be accessed and shared. The sharing is limited and controlled in a sense that a server issues a request, describing the criteria of a test item it requests, to another server. A server does not open up its item-bank for unlimited access.

Additional advantages have been identified and include the facts that since DIYexamer provides a real-time on-demand generation of test-sheet function, cheating is avoided. Also, DIYexamer provides an item cross-analysis function to which the degree of difficulty for each test as well as the entire test base can be accurately measured.

3 Diyexamer System Implementation

A. DIYexamer Network Architecture

DIYexamer is a WBT (WWW-Based Testing) system. An important feature is the sharing of item-bank via network connections. According to Fig 4, several DIYexamer servers form a *scalable test union*. Therefore, each server can access other servers and thus achieve item-bank sharing. A remote server can also join the test union to share additional test-bank resources, and leave the test union without affecting other servers.

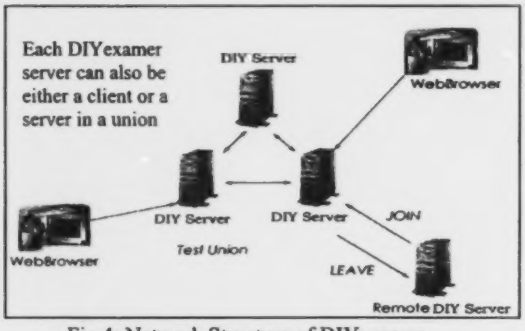

Fig 4: Network Structure of DIYexamer

B. Internal System Model

The internal architecture of DIYexamer (Fig 5) is divided into three layers. Interface layer is responsible for providing web interface for users. Test Profile Layer (TPL) selects items to form a test sheet, computes scores, and calculates the discriminability of selected test items. Test base Sharing Layer (TSL) accesses both local and remote databases via a network. Three functions of TSL are listed in Table 2:

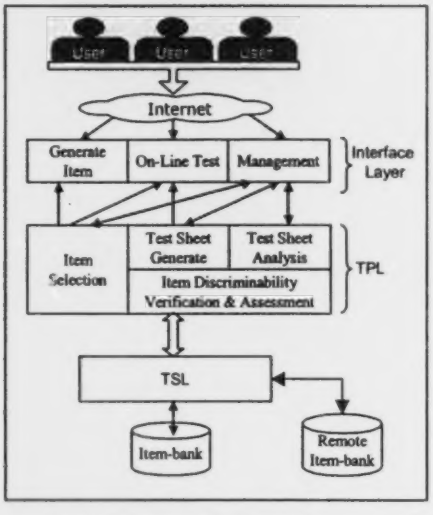

Fig 5: Structure of DIYexamer

TABLE 2: Functions of TSL

Function	Description
Add new items	New items and corresponding answers are categorized to specific chapters and stored in the local item-bank.
Access local item-bank	Accessing local while generating test sheets and calculating discriminability.
Connect to remote item-bank	Item-bank sharing through a connection to a remote item-bank.

Environments and development tools used to construct DIYexamer are listed in Table 3. Perl is used to write CGI programs to create user interface as homepage. Apache, an open source web server software, is responsible for front-end. The back-end, item-bank, is handled by Postgres.

TABLE 3: Environments and development tools

Function	Tools
HTTP Server	Apache 1.3.3 [8]
Programming Tools	Perl 5.003 [9]、CGI.pm-2.56 [10]、Gd.pn-1.14[11]
DBMS	Postgresql 6.5.3 [12]
O.S.	Red Hat Linux release 6.1[13]

C. Functionalities for administrators, teachers and students

DIYexamer provides a web interface for users to remotely control and operate the system. Three types of users are supported: administrators, teachers, and students. Corresponding functionalities are listed in Table 4.

TABLE 4: Functionalities for different users

	Administrator	Teacher	Student
System and Database	• Examine system status • Join a test union • Leave a test union • Create personal accounts • Create group accounts • Modify accounts • Modify item-bank • Redact course division • Backup database	• React course division	
Item production		• Create tests sheet • Select test items • Edit test items • Read test items	• Edit test items • Read test items
Test	• Network Invigilate	• Input scores of homework	• On-line test
Analysis	• Analyze tests • Analyze test items	• Analyze tests • Analyze test items • Analyze subjects and divisions	• Analyze tests
Inquiry		• Inquire tests • Inquire test items generated by students • Inquire students scores	• Inquire personal scores

4 Discriminability Assessment Of Diyexamer

A. Method of Traditional Discriminability Assessment

A criterion against which the quality of test items is judged is the assessment of discriminability. An item is regarded as with high discriminability when competent students correctly answered it, while less competent students incorrectly answered it, and vice versa. When computing item discriminability, those students with relatively high and relatively low scores are taken as samples. Those students whose scores fall in middle range not

considered. Next, item discriminability is computed according to the performance of these sampled students when answering each item.

In the traditional discriminability assessment method[14], those in the top 30% and the bottom 30% rank groups are chosen as samples. The top 30% scorers are defined as "high-rank group (H)", while the bottom 30% scorers are defined as "low-rank group (L)". The formula for calculating the discriminability of an item is as follows:

$$\text{Discriminability} = \frac{\text{The number of students in H that answered correctly}}{\text{The number of students in H}} - \frac{\text{The number of students in L that answered correctly}}{\text{The number of students in L}}$$

In the traditional method, two major drawbacks can be observed. The first one has something to do with whether the 30% is in terms of *count of students* or *range of scores*. The sampled students fall in the top 30% and the bottom 30% rank groups, i.e. in terms of *counts*. However, it is possible that these scores differ only slightly from the average score especially when scores are not wide-spread distributed, where many scorers should not be considered in computing the discriminability. Second, the effect on discriminability assessment by each student in either group is assumed to be the same. However, those students that received different scores have different degrees of tendency to correctly or incorrectly answer an item. For example, a sampled student who received 97 points should have higher referential value than a sampled student who received 80 points.

B. Method for DIYexamer's Discriminability Assessment

When selecting sample students, only those whose scores have large gap with the average score should be considered. Accordingly, those with the top 30%, in terms of range, scores are defined as "high-score group (H')", while those with the bottom 30% scores are defined as "low-score group (L')".

To show the different criteria and effects of choosing samples in the traditional method and DIYexamer method, Fig.6 depicts the score distribution in a test. In this example, the highest score is 92, the lowest score is 34, and the average score is 69. The "high rank score group" and the "low rank score group" are chosen according to these two methods. Take student X as an example, the score of X is 66, which differs only 3 points from the average score. The associated information of X should have little, if not none, referential value in computing item discriminability. However, X is chosen as a sample in the high rank group in the traditional method. This fallacy results from using rank group, in terms of count, as the criterion of choosing samples. In DIYexamer, X is not chosen since score group, in terms of range, rather than rank group is used. Only those with large gap with the average score are chosen as samples.

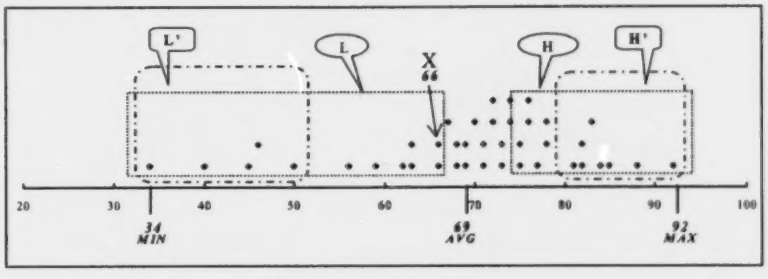

Fig 6: Comparison of samples taken in the traditional method and DIYexamer method

For different samples to have different impacts on discriminability, a referential value with respect to an item is generated for each student selected as a sample. We first define the item discriminability as the average of all associated referential values, as shown below:

$$\text{Discriminability} = \frac{\text{Sum of the referential values of sampled students}}{\text{Number of sampled students}}$$

Since the referential values depend on students' scores, the referential values are computed according to the ratio of correct and incorrect answers of the sampled students. The ratios of correct and incorrect answers are defined as follows:

$$\text{Ratio of correct answer} = \frac{\text{Number of items answered correctly}}{\text{Number of items on the test}}$$

$$\text{Ratio of incorrect answer} = \frac{\text{Number of items answered incorrectly}}{\text{Number of items on the test}}$$

TABLE 5: Principle to compute the referential value of a student with respect to an item

Student	Answer	Item discriminability	Referential value to compute discriminability
Competent (With high ratio of correct answer)	Correct	High	Ratio of correct answer
	Incorrect	Low	Ratio of incorrect answer
Less competent (With low ratio of correct answer)	Correct	Low	Ratio of correct answer
	Incorrect	High	Ratio of incorrect answer

According to Table 5, the referential value of a student correctly answered an item is the ratio of correct answer of the student. Alternately, the referential value of a student incorrectly answered an item is the ratio of incorrect answer of the student. This policy comes from the fact that an item should have increased discriminability if correctly answered by a competent student, while rendering decreased discriminability if correctly answered by a less competent student. In this way, a competent student contributes large referential value to a correctly answered item and small referential value to an incorrectly answered item, and vice versa.

C. Algorithm for DIYexamer's Discriminability Assessment

The test result of a student is used if the score falls in either the high or the low score group. A referential value is computed for each item the student answered. The discriminability of an item is the average of all of the associated referential values.

To calculate for each item, information must be recorded in the database. First, the highest and the lowest scores (i.e. Gmax and Gmin) of all students who answered the question item are recorded to calculate Gh and Gl. Gh and Gl are used as thresholds to determine whether a student is eligible to affect the rating of an item. Second, the number of students with referential values (i.e. n) and the sum of referential values (i.e. Accumulator) are recorded. The calculation formula and the corresponding definition of used parameters are listed below. Algorithm of DIYexamer's discriminability assessment summarized in Fig 7.

Accumulator: sum of referential values
n: number of students with referential value
T: number of correctly answered questions in this test
F: number of incorrectly answered questions in this test
Gmax: highest score of all students answered this question
Gmin: lowest score of all students answered this question
Gh: high threshold for ratio of correct answer
Gl: low threshold for ratio of incorrect answer
Ans: A Boolean variable indicates whether a student correctly or incorrectly answered the question

```
if((T/(T+F)>Gh) or (T/(T+F)<Gl))
{
 if (T/(T+F)>Gmax)
   Gmax = T/(T+F)
 else(T/(T+F)<Gmin)
   Gmin = T/(T+F)
 Gh = Gmax-(Gmax-Gmin)*30%;
 Gl = Gmin+(Gmax-Gmin)*30%;
 n = n+1;
 if (Ans==Correct)
   Accumulator = Accumulator + T/(T+F);
 else (Ans==Wrong)
   Accumulator = Accumulator + F/(T+F);
 Discrimination = Accumulator /n;
}
```

Fig 7: Discriminability assessment algorithm

5 Evaluation Of The Discriminability Assessment In Diyexamer

The fairness and performance of DIYexamer was evaluated. We conducted an experiment where 10 students took the test on-line using DIYexamer with 10 items. Table 6 summarizes the test results. Fig 8 shows the score distribution of the experiment. Discriminability for each item is computed using both the traditional method and the DIYexamer method. However, the discriminability originally falls between -1 to 1 using the traditional method, while falling between 0 to 1 using the DIYexamer method. To compare these two methods, both two ranges of discriminability are then normalized to 0 to 10, as shown in Fig 9.

According to Fig 9, the item discriminability differs in these two methods because the samples taken are different. The low-score group consists of student 1, 2, and 3 by the traditional method, while only 1 and 2 by the DIYexamer method. In this case, student 3 got 4 points, which differs from the average score (i.e. 5.2 points) by only 1.2 points. Since student 3 should have little, if not none, impact on the assessment of discriminability, student 3 is in fact not a proper sample.

Observe that, in Table 6, student 1 who is a less competent student and has incorrectly answered all items except item 1, and student 10 who is a very competent student and has incorrectly answered item 1. Thus, item 1 can be concluded as of low discriminability. Comparing the assessment results in these two methods, the computed item discriminability of item 1 is very low in the DIYexamer method but not as low in the traditional method.

Comparing item 3 and item 1 in Table 6, item 3 should have higher discriminability than item 1 because competent students tend to answer item 3 correctly and less competent students tend to answer item 3 incorrectly, which is not true for item 1. However, item 3 and item 1 have the same discriminability, i.e. 5, by the traditional method. In this case, the actual discriminability is more accurately reflected in the DIYexamer method than in the traditional method.

TABLE 6: Result of the test experiment

	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Number of correct answers(score)
student1	1 (correct)	0 (incorrect)	0	0	0	0	0	0	0	0	1
student2	1	0	0	1	0	0	0	0	0	0	2
student3	0	1	1	0	1	0	0	1	0	0	4
student4	1	1	0	1	0	0	0	1	0	1	5
student5	0	1	0	1	0	0	1	1	0	1	5
student6	1	1	1	0	0	1	0	1	1	0	6
student7	0	1	1	1	1	0	0	1	1	0	6

student8	1	0	0	1	1	1	1	0	1	1	7
student9	1	0	0	0	1	1	1	1	1	1	7
student10	0	1	1	1	1	1	1	1	1	1	9

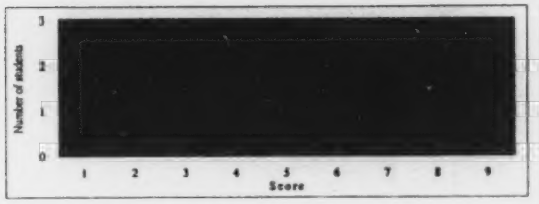

Fig 8: Score distribution of the test experiment

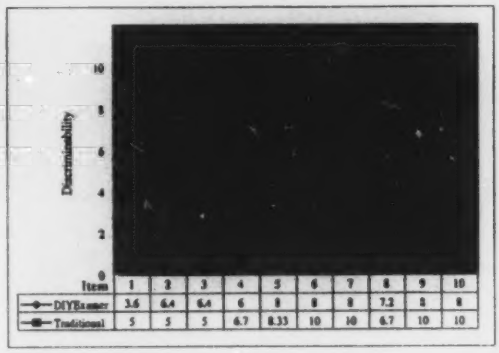

Fig 9: Comparison of item discriminability

6 Conclustion

This paper has presented a novel architecture for a networked CAT system, DIYexamer. It supports item DIY by students, item-bank sharing, and item discriminability assessment.

For discriminability assessment, new calculation formula were proposed. When compared with the traditional assessment scheme, the main difference is that the top and the bottom 30% of the *score* group, in terms of *range of scores* were selected rather than the *rank* group, in terms of *count of students*. Thus, item discriminability is more accurately reflected particularly when the tested students have close scores.

Item-bank sharing and item DIY by students has increased both the *amount* and the *variety* of questions in item-banks. Item DIY by students promotes *creative learning* within students, while automatic discriminability assessment assures better quality than traditional CAT systems.

A questionnaire was used to survey subjective attitudes of students about DIYexamer. As shown in Table 7, the outcome revealed that most students were interested in item DIY.

TABLE 7: DIYexamer questionnaire results: percentage and the number of students in parentheses of each question

Question	Strongly agree	Agree	No opinion	Disagree	Strongly disagree
Item DIY is interesting.	12.3 (7)	43.9 (25)	21.1 (12)	15.8 (9)	7.0 (4)
Item DIY is fanciful.	19.5 (10)	49.1 (28)	21.1 (12)	10.5 (6)	1.8 (1)
I am curious about the testing result of my DIY item.	26.3 (15)	59.6 (34)	10.5 (6)	3.5 (2)	0.0 (0)
I learned a lot when creating items.	12.3 (7)	47.4 (27)	22.8 (13)	17.5 (10)	0.0 (0)
I am curious about the teacher's opinion about my DIY item.	22.8 (13)	50.9 (29)	22.8 (13)	1.8 (1)	1.8 (1)
I am curious about other students' opinions about my DIY item.	15.8 (9)	56.1 (32)	21.1 (12)	7.0 (4)	0.0 (0)
I studied harder to prepare item DIY.	10.5 (6)	54.4 (31)	21.1 (12)	14.0 (8)	0.0 (0)
Judging the difficulties of my DIY items is easy.	40.4 (23)	38.6 (22)	14.0 (8)	7.0 (4)	0.0 (0)
Judging the fitness of my DIY items is difficult.	36.8 (21)	49.1 (28)	8.8 (5)	5.3 (3)	0.0 (0)
Item DIY by students comes from the laziness of teachers.	7.0 (4)	12.3 (7)	43.9 (25)	33.3 (19)	3.5 (2)
If possible, I hope such item DIY mode through the whole course can replace conventional testing.	1.8 (1)	10.5 (6)	35.1 (20)	38.6 (22)	14.0 (8)

Items generated by students are easier than by the teacher.	7.0 (4)	36.8 (21)	28.1 (16)	24.6 (14)	3.5 (2)
I knew more about the testing material after item DIY procedure.	8.8 (5)	50.9 (29)	22.8 (13)	15.8 (9)	1.8 (1)

The technique proposed herein is useful in general tuition not only to improve the quality of test items and fairness; but also to save time from generating questions and computing scores. We recommend that DIYexamer be popularized to schools.

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EDASEQ – A log file analysis program for assessing navigation processes

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Research on the effects of hypermedia learning environments often suffers from a lack of systematic control of learning conditions, especially the sequencing of the content. While available tools for logfile analysis are confined to delivering frequencies and other figures, the tool to be presented (EDASEQ: Exploratory Data Analysis for Sequential Data) was developed to facilitate the analysis of the navigation paths of single learners as well as "average" paths of a group of learners. Because standard statistical procedures for handling sequential data are not suitable here, the tool is primarily founded on graphical methods. Navigation processes are represented by transition matrices, and with additional visualizations and trajectories. Apart from descriptive portrayals, the tool also allows for categorizing empirically found navigation patterns on the basis of theoretically defined prototypical patterns. Furthermore, it is possible to compare the patterns of single learners or groups. Results can be used to better explain the effects of self-regulated learning in hypermedia learning environments. Without knowing variables like sequencing, time-on-task, or the number and configuration of examples studied by learners, it is hardly possible to interpret the impact of external learning conditions on the learning outcomes.

Keywords: **learning processes, navigation, hypermedia, methodology, tool**

1 Introduction

A fundamental problem of research on self-regulated learning is the possible variation of learners' behaviors, especially regarding variables like the sequence of content, the time spent with studying different parts of subject matter, the number and arrangement of examples and exercises: Have they really worked through all the relevant information? How many examples were chosen, with what methods of representation and in what combinations? How many exercises were worked through, and to what result, resp. with mistakes of what kind? How long were the learners occupied with what contents? This is valid for every type of research on self-regulated learning, but especially for learning with hypermedia. Even with the same context conditions, quantitatively and qualitatively completely different courses of learning are possible and thus, in consequence, very different results. Even when the learner activities displayed are described exactly, there are differences with respect to the quality of the elaborative treatment; the external conditions of the learning processes, however, are principally controllable. Unfortunately, standard statistical procedures are not suitable to represent an "average path" in an educational hypermedia system: Mean times spent on looking to specific pages or mean frequencies of visits are often not sufficient to explain differences in learning outcomes.

2 Aims of the development of EDASEQ[1]

For the description and categorization of such processes there thus remain graph theoretical procedures. There were already attempts at implementing these some time ago; the best known is probably Flanders' (1970) procedure for the analysis of teaching (cf. also Canter, Rivers & Storrs, 1985). For the treatment and

[1] Supported by the Deutsche Forschungsgemeinschaft (German Research Foundation), grant Az. Ho 649/9-1,2,3).

evaluation of data on the basis of graph theoretical considerations there is, however, as yet no method which is relatively simple to use. It was therefore an aim of the development of methods within the framework of a six year research project on case-based hypermedia learning environments in vocational training to develop a procedure allowing recorded data of learning processes to be so prepared that a) a data reduction is brought about which allows those processes to be analyzed exploratively, b) a categorization of typical processes becomes possible, c) records of several processes can be aggregated and finally d). Comparisons are made possible between (1) single records of processes, in order to see differences and similarities, (2) an individual process and an aggregated one, in order to be able to study deviations of single learners from the typical route taken in their group, (3) two aggregated processes, in order to compare groups under different treatment resp. marginal conditions using experimental designs, (4) a single or an aggregate process with a prototype process that is produced artificially, in order to categorize processes of one or several prototypes within the framework of defined deviations, or to test hypotheses. Apart from the characteristics of the processes, it should also be possible to extract simple statistics: e.g. frequency of the calling up of specific screen pages, specific transition frequencies, length of stay etc.

3 Forms of representation

In order to represent hypermedia navigation processes, there are first of all two different but mathematically equivalent codes: transition matrices on the one hand and aligned graphs on the other. Whilst one can see conspicuous characteristics in the graphical representation, the matrix representation allows the calculation of indices. Since both forms of representation are practicable, both should be taken into consideration. One special feature of well designed hypermedia learning systems is a structured presentation of knowledge given in such a way that learners have the choice of either informing themselves superficially or of going deeper into the subject at any chosen place, or of conbining both courses of action: first gaining an overview, then deepening their knowledge. In order to determine the extent of the "deepening" - assuming an appropriate structuring of knowledge in the medium -, two characteristic values, the mean "depth of elaboration" and the "variance of elaboration" have been developed. The depth of elaboration is a rating for every hypermedia occurrence, which is all the higher, the deeper the corresponding screen page goes into a specific subject. If, for instance, the highest level with the index number 1 is the term "statistics", then pages on the subject "inference statistics" or "descriptive statistics" would have the index number 2 and a page on the subject "log-linear models" would have, for example, the index number 5. The arithmetic mean of the values of all screen pages visited could then give an indication of the extent of the "deepening" or "elaboration" of the material; the measurement is completed by the elaboration variance ascertained analogously. Not least, characteristics of the chronological process should be portrayable.

4 Realization

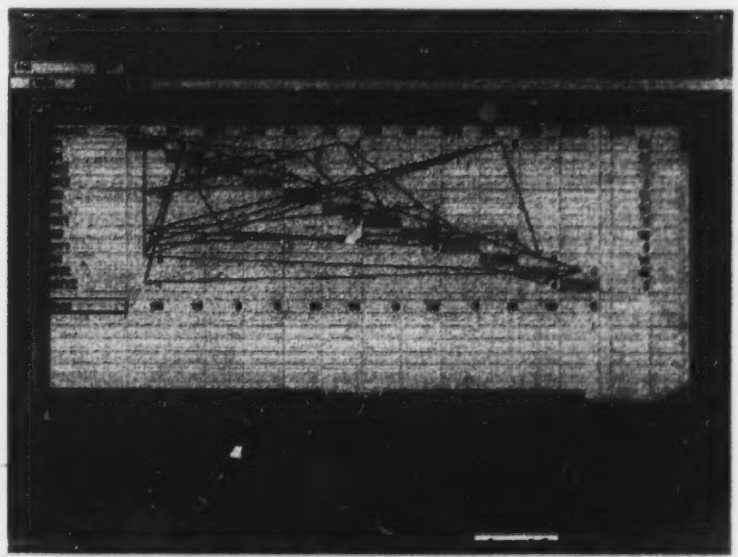
As the first step towards a reduction of process data in the Mannheim research project "Case-based learning problem" - in compliance with the demands - a software-technical evaluation procedure was developed. This enables processes to be transferred rapidly into transition matrices, so that firstly the simple frequencies of the consultation of specific pieces of information and of the transitions between offers of information can be ascertained. The learning programs developed in this project each encompass approx. 150 screen pages; learners need up to five hours to complete the given tasks and corresponding records comprise 3000 - 5000 single entries, each consisting of the time (in seconds after midnight) and the designation of the respective screen page. Log-files existing as ASCII text files are downloaded and converted into MS Excel files. For the simultaneous treatment of a larger amount of records it is also possible to stack them. Process data in the form of transition matrices can furthermore be compared to each other and also aggregated. In order to reduce data one can also stipulate that transitions which are more seldom than a specified threshold value should be ignored.

5 Examples of process representations and indices

The following representations are based on fictitious data; i.e. records were produced with the specific aim of representing certain processes, in order to determine whether the corresponding characteristics are perceptible. Apart from this the size of these records was to be restricted, in order to enable a written account to be given. shows the evaluation as regards the frequency with which single screen pages were called up, as

well as the length of the stay there (absolute in seconds and relative to the complete time needed). Ills. 1 shows a transition matrix with aligned graphs of the process included (option). One alternative graphical representation ("chronological") is given in Ill. 2. Here, above all, recourses to previous steps are clearly to be seen: the test person would, in this case, have chosen a strategy whereby he/she began by choosing page B1 on the higher level, "deepening" from there straight to BX1, going back to B1, choosing another "deepening" (BY2) etc. The values in the main diagonal indicate how many time units the learner has here stayed on each separate page.

In a third, more concise representation of the process every node (page, screen, chapter etc.) is represented by one cell and the navigation process is shown by arrows between the cells. Analyzing aggregated data, the thickness of the arrows indicates the frequency of the transitions between two nodes. So, a sequence of thick arrows represent a "modal path", i.e. a path used by many users. (Ill. 3)



Ill. 1: Transition matrix with process graph included (A1, B1 etc. indicate screen pages)

Ill. 2: Linear representation of the process (A1, B1 etc. indicate screen pages)

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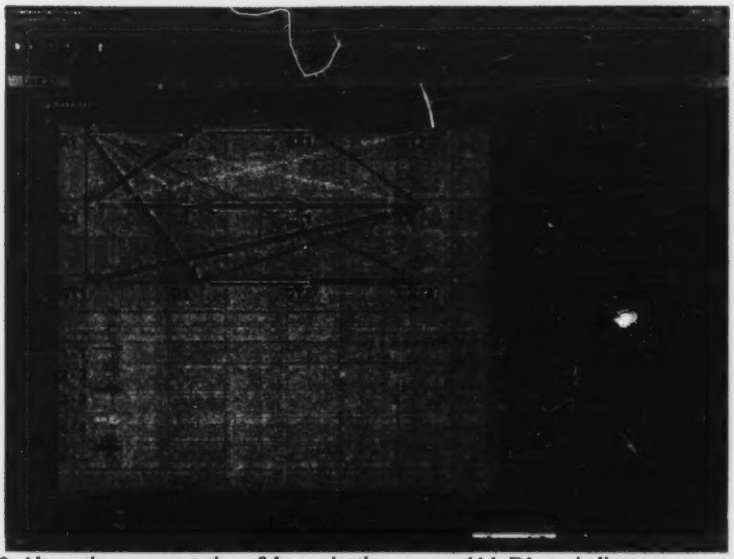

Ill. 3: Alternative representation of the navigation process (A1, B1 etc. indicate screen pages)

6 Conclusion

The procedure which has been developed is first of all explorative, i.e. data are so prepared and represented that they allow categorizations and comparisons, thus offering a basis for the forming of hypotheses. Very extensive record files, in particular, are reduced. Although the procedure for the analysis of records on navigation was developed in hypertext, resp. hypermedia systems, it is also suitable for the treatment and analysis of data on the observation of teaching or other courses of communication.

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Generating interactive explanations by using both images and texts for Micro World

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In this paper, we propose a method of constructing an intelligent Micro-World (MW) for high-school chemistry that accepts learners' questions and advises them whenever the learners are working in the MW. We also discuss the method generating explanations using both texts and images. At first, we argue on the interaction between a learner and such a system, and classify learner's typical demands and possible educational supports by the system. Next we show the ability necessary to deal with the demands, such as recognizing learners' plan, generating a plan to achieve a goal of an experiment, reproducing the state at any step of the change in MW, controlling the initiative of the interaction, and so on. Then we propose methods in order to realize the abilities. Moreover, we illustrate how to implement the abilities and introduce our prototype system.

Keywords: **Micro World, Interactive explanation, Mixed initiative**

1 Introduction

Micro-World (MW) has a problem that it is hard to support learners who are in impasse. We are developing an intelligent MW that supports the learners[1,2,4,5]. The domain subject of the MW is high-school chemistry. The MW has the following functions:

- Simulating changes in the world model of high-school chemistry.
- Recognizing the learner's plan by a sequence of his manipulations.
- Judging weather the learner is in impasse, by comparing the learner's plan with the standard plan that the MW generates. If the learner is in impasse, it assumes that the cause of the impasse might be lack of the knowledge necessary to perform the next manipulation which the learner should do.
- Giving the learner some advices by using texts. For example, the MW shows the knowledge which the learner doesn't understand, the manipulation that the learner should do next, and so on.
- Accepting learner's questions at any time when the learner is working in the MW, and answering by using texts.

Our MW uses only texts in giving advices. In general, it is effective to explain something by using both texts and images. CINESPEAK [3] is one of the systems which can show explanations using both images and texts. It can generate a 3D animation and texts of explanation. It also can select appropriate camera shot corresponding to the contents of explanation. However, It can not generate explanations interactively.

We think it is necessary to avoid showing the texts and images prepared beforehand like video movies with some captions. The reason is that the explanation should be shown interactively. In other words, an educational system must not explain anything one-sidedly, because the condition of a learner is changing moment by moment while the system explains to the learner.

When an idea flashes upon a learner's mind during the explanation, the system must allow him to say his idea and respond to his remark. For example, when the system explains how to solve some problems in MW

to the learner who is in impasse, if the learner requires doing continuation of the problem solving process by himself, the system should prepare MW and let him continue solving the problem on MW. Similarly, if the learner requires changing some conditions of MW and explaining the method of solving the problem, the system should stop explaining, re-plan a new method to solve the problem with new conditions, and explain it.

In this paper, we extend the user interface of our MW in order to make it more effective. The first extension is that the MW uses not only texts but also images when it shows the learners advices or explanations. The second one is that the MW generates explanations interactively. Our extended system can explain manipulations that a learner performed in a MW and the manipulations necessary to achieve a given goal by using both texts and animations simultaneously. Moreover it can explain interactively according to the learner's demand.

In the next section, we discuss the ability necessary for the system that generate explanations interactively. In section 3 we show our basic approach to realize the abilities. In section 4 we illustrate how to implement the abilities, and we introduce our prototype system and show examples of its behavior.

2 Interactive method to explain

In order to generate explanations interactively, the system should have the following two functions.
- When a learner does not express his intention, the system must be able to lead his learning.
- The system must be able to deal with a learner's demand whenever the system aids learning (even when it is explaining something to him).

The former is out of range of this paper, because it is the topic concerning to the teaching strategy in the field of Intelligent Tutoring System (ITS). Therefore, We concentrate the latter.

Learners' demands and the method to deal with them depend on what kind of educational supports can be provided by the system. Therefore, we must clarify:
1. the educational supports and learners' demands.
2. what kinds of ability are necessary to deal with the demands.

2.1 Possible educational supports and learners' demands

We can classify states of the system into the following two types:
- The system gives a goal and the learner manipulates the MW on his own initiative.
- The system takes the initiative then it shows advice or explanations to the learner.

We discuss learner's demands and methods to deal with them on each state.

2.1.1 Supports and learners' demands when learner has initiative

We think the major demand on this state is to require an advice to resolve a learner's impasse. Therefore, we deal with only such type of demands as the first step of our research. In order to discuss how to deal with the demands, we classify causes of learners' impasse into the following two types.

(A):• A learner cannot understand the current state of MW.

(B):• A learner cannot decide what to do in the next step.

The system can satisfy the demand of the learner who is in impasse because of (A) by showing the following explanations:
- Explanation of a sequence of manipulations that the learner performed in the MW and the effect of each manipulation.
- Explanation of the state after each manipulation has performed.

The demand of the learner who is in impasse because of (B) can be satisfied by various ways. For example, the system identifies misunderstood or lacked knowledge and shows him the knowledge, the system explains on the similar case and lets him remind his experience, and so on. In this paper, we adopt the simplest way that the system shows the actions to be performed in the following steps. If we take the other way, we need to extend some functions to decide contents of explanations. However, the mechanism to control interactive generation of explanations is commonly reused.

As a result, the type of demands of the first state is only a demand to require some advice, and the type of explanations that the system generates is only an explanation of manipulations and the state after each one. In order to explain a manipulation and the state after it has been performed, the system generates animation showing how to perform the manipulation in the MW and texts explaining the effect of the manipulation.

2.1.2 Supports and learners' demands when the system has initiative

First, we discuss typical demands of learners who are in impasse because of (A) mentioned in the previous section. When the system explains to the learner a sequence of manipulations that the learner performed and the state after each manipulation by using animations and texts, the learner may demand that the system shows him a previous state again or a following state intermittently. In case that the learner finds his own mistakes while the system is explaining something to him, he may demand that the system stops explaining, prepares the initial environment, and lets him re-try solving his problem on the MW again. If the learner fails to resolve his impasse in spite of some explanations generated by the system, he may demand that the system show him the whole correct process to achieve his goal on the MW.

Then, we imagine typical demands of learners who are in impasse because of (B). In this case, the system explains him the action to be performed in the following steps. The learner may demand that:
- the system shows him the previous/following states.
- the system stops explaining in order to let him do continuation of manipulations.
- he rewrites some conditions of his problem and the system explains how to solve the problem with new conditions.

We don't argue on all of above-mentioned demands, but only ones with which our system can deal, considering possible actions by our system. Such actions are as follows:
(1) Explaining the sequence of actions which learners have performed.
(2) Explaining the sequence of correct actions by which the given goal can be achieved.
(3) Setting an environment for experiment to let learners try achieving the goal free.

Table 1. Examples of typical demands by learners

Actions of the system		type of the demand and the scene where the learner input the demand
Action before the demand	Action after the demand	
(1)	(1)	The learner wants to see another action than one shown in the current explanation on the sequence of his previous actions.
(1)	(2)	The learner can understand what he has done, and wants to see what he should do next.
(1)	(3)	The learner finds the mistakes he has made, and wants to re-try the experiment.
(2)	(1)	The learner understands correct actions, and wants to compare it with what he did.
(2)	(2)	The learner wants to see another action than one shown in the current explanation on the sequence of correct actions.
(2)	(3)	The learner understands the correct actions, and wants to re-try the experiment.
(3)	(1)	The learner loses the current state in the process of achieving the goal of the experiment. He wants to confirm the actions which he has performed.
(3)	(2)	The learner loses the way to achieve the goal of the experiment. He wants to see the correct actions.
(3)	(3)	He finds he has failed to achieve the goal and wants to re-try the experiment.

Then we can classify the demands according to which actions are performed before/after accepting the demand. Combinations of the actions are 3*3= 9 types such as "when system doing (1), a demand is input, then it does (1)", "when it doing (1), a demand is input, then it begins to do (2)", and so on. Examples of the typical demand of each type are shown in Table 1.

2.2 Abilities necessary to deal with learners' demands

In this section, we discuss abilities necessary to deal with the learners' demands mentioned in 2.1. Basically, MW should have an ability to simulate changes in the MW according to learners' actions.
In addition, in order to deal with the demands mentioned in 2.1.1, the system should have the following abilities.

(a) Ability to recognize learners' plan from a sequence of his actions.

In order to explain what learners have done by not only listing up the actions, but also showing the meanings of the sequence of the actions, the system needs the ability.

(b) Ability to generate a plan to achieve a goal of an experiment.

In order to explain correct actions which learners should perform, the system has to be able to generate plan.

(c) Ability to simulate changes in the MW according to the plan generated or recognized by itself, and ability to generate verbal explanations showing what actions has been done or what actions should be going to be done.

The system had better be able to generate explanations using both texts and images. In order to generate visual explanations, the system should be able to operate MW in a similar way as learners do. In order to generate verbal explanations, the system should be able to generate texts from the result of planning or plan recognition.

In order to deal with the demands mentioned in 2.1.2, the abilities mentioned above are also necessary. In addition, the following abilities are needed.

(d) Ability to store the history of actions by learners or the system.

The ability is needed to do action (1) or (2) as a reaction of a demand in Table 1.

(e) Ability to reproduce the state at any step of the change in MW and allow learners to manipulate the MW.

The ability is needed to do action (3) as a reaction of a demand in Table 1.

In addition, the following ability is necessary to realize mixed initiative. It is generally important to make interactive educational environment effective.

(f) Ability to control the two phases: a phase where a learner takes initiative by actions to achieve the goal, and a phase where the system takes initiative by generating explanations.

3 Methods necessary to deal with learner's demand

The basic framework of the system as a MW can be seen in [5]. An extension in this paper is that the system becomes to have two individual environments: one is the environment for experiment used by learners, and the other is the environment for explanation. Our system operates the latter environment in its explanation. We add the latter environment in order to avoid that both a learner and the system try to operate a common one at the same time. The environment for experiment has an interface and functions to accept learner's actions, and reacts as soon as it accepts an action from a learner. On the other hand, the environment for explanation cannot accept manipulations from learners (though switches similar to the environment of experiment are displayed in its window, they are dummy).

We discuss how to equip such a framework of the system with the abilities mentioned in 2.2.

(a) Ability to recognize learners' plan from a sequence of his actions.

On this ability, please see our previous paper [4, 5].

(b) Ability to generate a plan to achieve a goal of an experiment.

On this ability, please see our previous paper [4, 5] too.

(c) Ability to simulate changes in the MW according to the plan generated or recognized by itself, and ability to generate verbal explanations showing what actions has been done or what actions should be going to be done.

Simulation in MW is performed by using symbolic knowledge representation. States at each step of

MW are also represented in a symbolic way. Manipulations by learners are also translated to symbolic representations. The control method of the simulator is event-driven: as soon as a manipulation is input to the simulator, the inference engine generates symbolic representation showing the next state of MW. The system draws the state of MW on the basis of the symbolic representation. Therefore, the system can simulate changes in the MW according to the generated or recognized plan, because the system can generate the input of the simulator represented symbolically from the plan.

In addition, because states of MW, manipulations to MW, and changes in MW are commonly represented in a symbolic way, the system can generate explanations in natural language on every fact in MW.

(d) Ability to store the history of actions by learners or the system.

It is easy to store such history because all of states of MW, manipulations to MW, and changes in MW are represented in a symbolic way. The system records only the initial state and a sequence of having performed actions as the history. The system can reproduce all states and changes by simulating the change in MW again on the basis of the history.

(e) Ability to reproduce the state at any step of the change in MW and allow learners to manipulate the MW.

The system can reproduce any states in an explanation on learner's previous actions, by performing the manipulations stored as the history sequentially. On the other hand, it can also reproduce any states in the process when correct actions are performed, by performing the manipulations in the plan generated by itself. Thus, the system can set any states of an environment which learners can manipulate, by copying such reproduced states in the environment for explanation to the one for experiment.

(f) Ability to control the two phases: a phase where a learner takes initiative by actions to achieve the goal, and a phase where the system takes initiative by generating explanations.

We adopt the following strategies for controlling the phases:

- Basically, a learner takes initiative, and he acts freely in MW.
- Turn over the phase to the other phase where the system takes initiative, as soon as the learner inputs a question or demands that the system explains something.
- If the system finds that the learner is in impasse, ask him whether he hopes to turn over the phase where the system takes initiative. And if he does, turn over it.
- Accept interruption by learners whenever the system generates explanations.
- Decide the next action of the system according to the interruption. For example, if the learner demands that the system sets the phase where the learner takes initiative, set a suitable state of the environment and let him experiment freely. If he inputs a demand for the system to explain other topic than the current topic, continue explanation on the requested topic.

4 Implementation

We designed a prototype system. Figure 1 shows outline of our system.

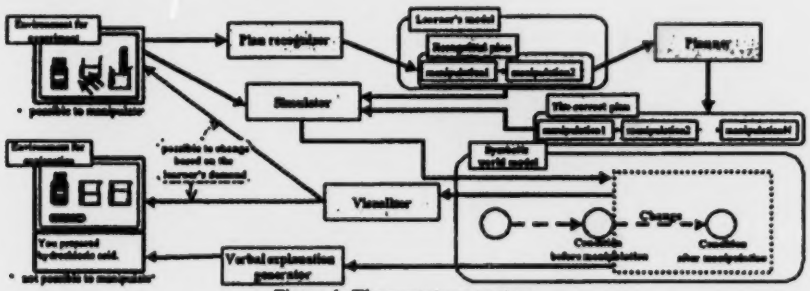

Figure 1: The prototype system

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The system has *environment for experiment* and *environment for explanation*. The system sets a goal and a learner tries to achieve the goal by manipulating objects in *environment for experiment*. When the learner does an action in *environment for experiment*, the simulator reproduces a change in *symbolic world model*. Then the *visualizer* draws the state after the change in *environment for experiment*. At the same time, *the plan recognizer* monitors the learner's manipulations and recognizes his plan. When the learner becomes to be in impasse or requires some advice, *planner* generates a correct plan. Then the system visualizes environment for explanation, and starts explaining by using either recognized plan or the correct plan. In order to generate explanation, *simulator* reproduces states of the world model and *visualizer* visualizes the states in *environment for explanation*. Simultaneously *Verbal explanation generator* generates verbal explanation on the manipulation, the change, and the state.

The domain world model of this system is written by symbolic representation. In general, it is difficult to handle continuity of time and space by such representation. Therefore, our system handles time as a sequence of discrete segments of time. And it doesn't handle strict position of objects in the world, but only relative relations which can be represented by symbols, such as "chemical materials are in the same beaker". A change is also represented by symbols which shows the initial state, the actions causing the change, the changing state, and the state after the change. Most of the subjects in high-school chemistry can be handled in the above mentioned way.

This system is implemented by using Tcl/Tk and LISP (Kyoto Common LISP). This system can deal with the 5 subjects: method of preparing a solution of a certain molarity, acidic material, basic material, neutralization, and using indicator.

We show an example of the behavior of our system when a learner does an experiment of neutralization. Figure 2 shows a user interface for *environment for experiment*. In the environment, the learner prepares hydrochloric acid, prepares nitric acid, and sodium hydroxide, pours nitric acid into hydrochloric acid, prepares phenolphthalein, and mixes it into the mixed acid. Then he finds that he has not achieved his goal. In the case that he can't find the reason and inputs a demand for the system to explain his own actions, the system prepares an *environment for explanation* to start explaining the actions the learner has done. Figure 3 shows a user interface of *environment for explanation*. The interface has three windows: a window for displaying visual explanations and verbal explanations, a window showing a history of actions that have been taken place, and a window for inputting demands. In Figure 3, both visual and verbal explanations for the fourth action (marked in the list shown in the window for history). If the learner finds that he has made a mistake, and if he cannot find the correct way, he wants to demand that the system explains how to neutralize. He clicks on the button "*correct manipulation*" in the window for inputting demands. Then the system starts explaining the correct way (Figure 4). If he inputs a demand for the system to let him re-try the experiment, the system prepares *environment for experiment* and reproduces the state from which he wants to start experiment (Figure 5).

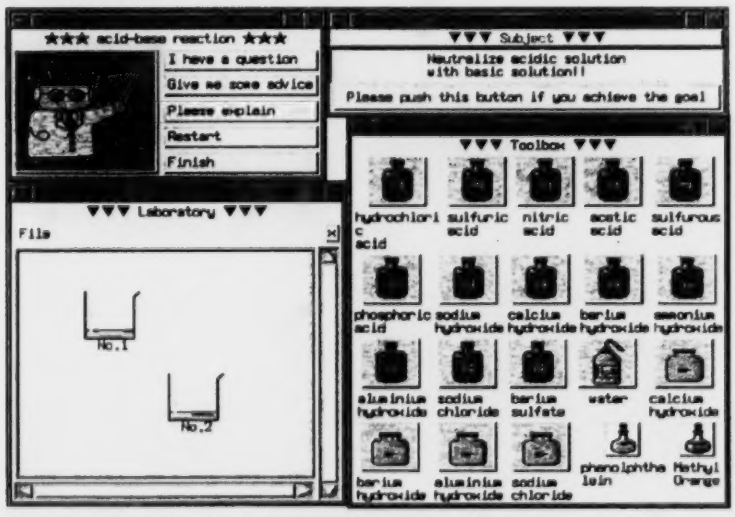

Figure 2: An example of environment for experiment

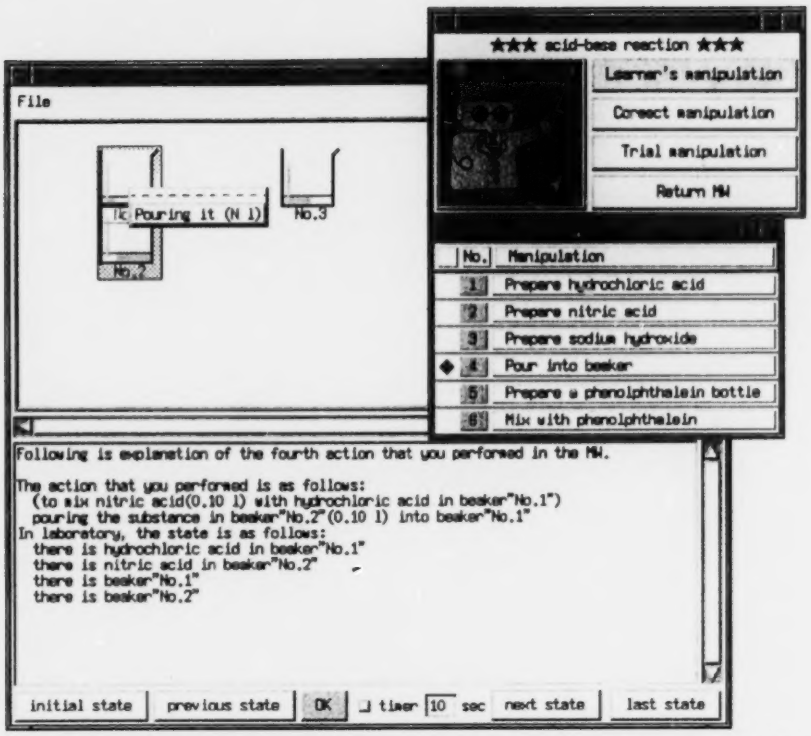

Figure 3: An example of environment for explanation (Explanations of a learner's actions)

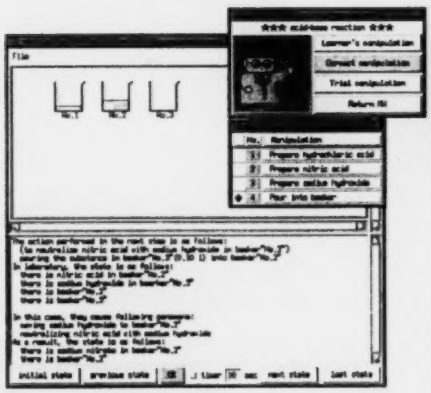

Figure 4: Explanations of corrects actions

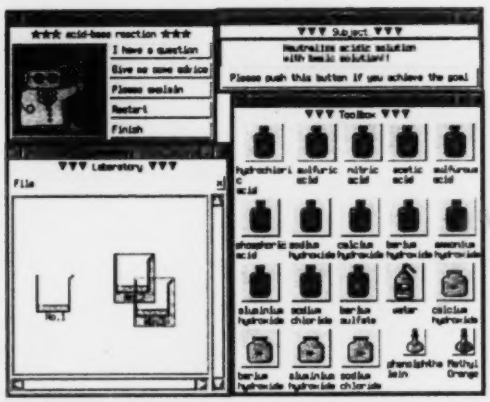

Figure 5: A reproduced environment for experiment

5 Conclusions

In this paper, we discuss a method constructing an intelligent and interactive MW generating explanations both images and texts. Our prototype system has relatively small domain knowledge base, so we have to make it larger in the future in order to increase subjects that our system can support.

When we will try to extend our system to handle other domains, the simulator underlying the system needs to deal with continuity of time and space. For example, if we deal with the field of electric circuit, the

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simulator needs to handle topology. If we deal with the field of dynamics of physics, the simulator needs to handle coordinate system.

Our another future work is to evaluate the effectiveness of our system experimentally.

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Gold Peach Web Community 2000: A Research on Developing Web-Based Interactive Learning Environment

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This series research was based on the progressive concepts of web community, cultural and cultivation features to develop an interactive learning environment for children. The series was conducted from 1996 to 2000. There were four generations of web-human interaction and user interface has been developed and tested. There were four functions in this community: total Web-Based CAI, interactive learning navigation, collaborative learning classroom, and community management.

Keywords: **Web-Based Learning, Interactive Learning Environments, Web Community, Culture and Cultivation**

1 Introduction

This series research attempted to access the specific objectives as follows:
Developing an interactive learning platform 'Gold Peach' for children based on the fundamental ideas of 'web community'.

Initiating the 'cultural' and 'cultivation' features on designing web environment.
Conducting a field study on focus groups to testify the usability of 'Gold Peach'. Two pretest groups have been done. A well-designed quasi experiment including 3 primary schools is still under going.

The series was conducted from 1996 to 2000. There were four generations of web-human interaction and user interface that had been developed and tested.

2 Literature Review and Problems Defining

2.1 Web Community

Web community was a progressive and extended concept from 'network-based learning community' that was introduced by Lave ea al. (1991)'s 'situated learning' and modified by Qiou (1996).

The components of network-based learning community were:
The organization of community: There were hardware, tools, and members. The community could be in an open or a closed form.

The learning activity: Lave et al. (1991) indicated it should have legitimate peripheral participation (LPP). Such participations included access, communication, learn to talk, collaborative learning and knowledge sharing.
The learning material: There were both existing material that was prepared in the learning database and

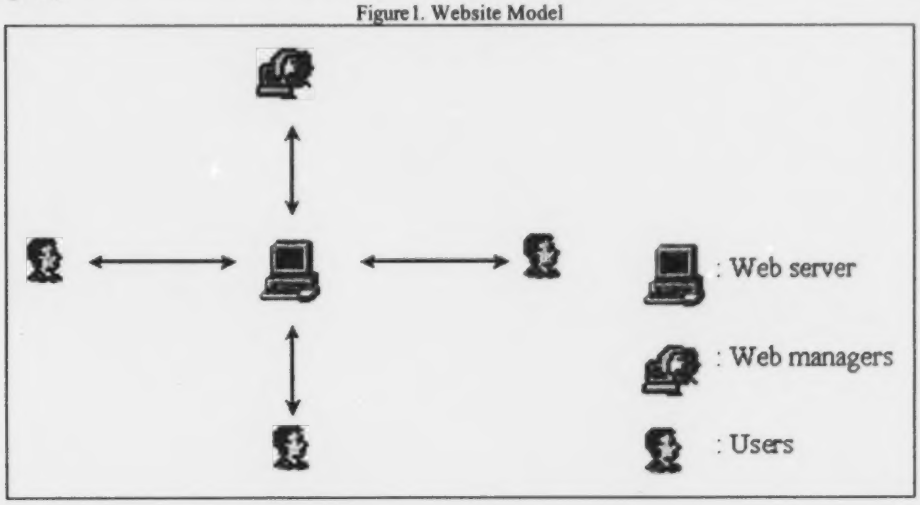
ongoing knowledge that was shaped by the collaborative learning processes.

The moderation: Lave et al. (1991) did not point out any leader in the community while Qiou (1996) advocated the necessary role of 'moderator' who would be the teacher to the other users (students). However, Kearsley (1997)'s idea could be noted here. He emphasized an online teacher is to coordinate the learning direction more than to dominant dogmatism.

After examining the literature above, the author suggested there should be the fifth element: 'the integrated interaction model'.

In general, the conceptual modes of websites interaction could be described as 'radiation model' (see Figure 1):

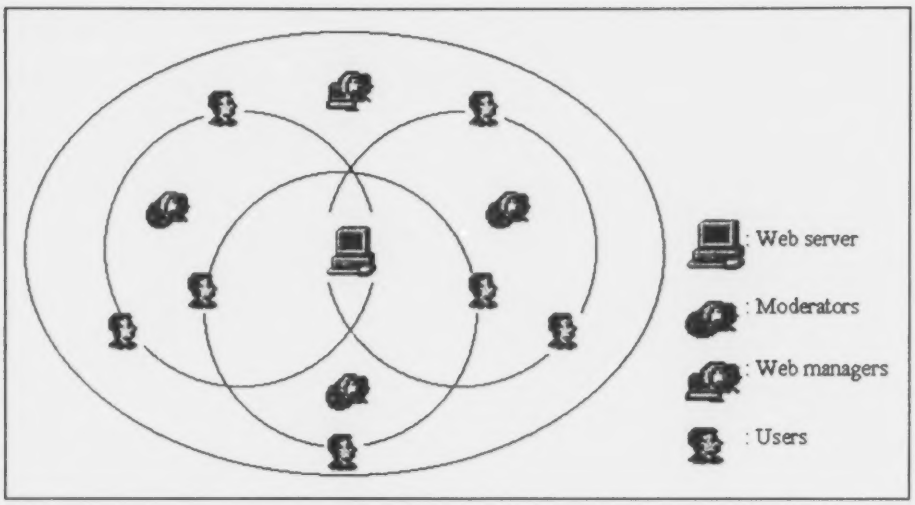
Figure 1. Website Model



The website manager has a 'one to multiple' interaction with users through internet. The website manager will provide all web function, service content and all learning activities.

n practice, it is impossible to prepare complete and sophisticated learning material, achievement test, and all peripheral participation by a single manager or few individuals. It reflects the facts that a lot of existing learning websites that are lacking of updating or content depth.

Figure 2. Web Community Model



Therefore, the author brought a new ' web community model' as Figure2.

This model designed two different interactions: systems functions and information contents. The website manager would only take the former responsibility. The information contents would be divided into more sub communities or interest groups that would be coordinated by external moderators. It was expected that there would be some interlaced area between groups, thus it would be linked as an integrated community. Group moderators did not have to worry about the web techniques; they could be concentrated to develop the learning behavioral interaction for users.

2.2 Culture

Internet makes the earth smaller, brings the world into a village. When we are celebrating the international boundary is falling down; do we regret that the pluralistic colors are also vanishing?

Though there are millions web sites, we have found the inevitable trend that the web characters grow similar faces, wear same uniforms, their interactions are more and more following consistent pattern. We cannot tell which web site is from a certain corner of which continent.

It worried him when the author called for a seminar of designing a new web with his college students. When we needed an innocent leading actress, there was only Snow White left in students' mind; when we made up a worrier model, the Black Knight came out; when we set up exploring plots, they were thinking of Star Trek. They ignored or forgot there are plenty of symbols and scientific fictional stories in Chinese history and mysteries. The young generation is losing its heritage of cultural imagination. (Wu, 1997)

The author suggested that we should remind web designers to consider ' cultural feature' to be an essential factor for designing web. It would be not interesting, if there were no cultural differences in the cyber world. (Wu, 1998; Wu et al. 1999)

2.3 Cultivation

Media' s form (or environment) is as well as content may produce cultivation effect to children, according to Gerbner et al. (1979)' s series work concerning Media Sociology perspective. This idea may come from a long tradition of 'The Medium is the Message' (McLuhan, 1966). It argued that media itself would affect audience' s recognition, attitudes, and even behavior.

There were rich studies and documents on 'TV cultivation theories' in 1970s and 1980s. (Anderson, 1980; Hughes, 1980) Scholars advocated that there are heavy effects influencing children by television. They also

found television would build up a 'media reality' which is far different from the 'real reality'. 'TV children syndrome' was discovered and considered a serious problem.

However, there was still a positive angle to this effect. We could conclude that although media might distort one's behavioral development, while it also might inspire one's mental potential especially in his/her childhood.

WWW is the most powerful media next to television. When we reviewed the lessons from television, the author wanted to suggest that developing web is not only defining a mechanism but also initiating an organism that might cause cultivation between community members.

The effect of cultivation could be operationalized and explored by users' behavioral changes after their experiencing the new media's form and environment. Therefore, the web community also needs a two-way feedback system to collect, measure, and interpret data that real users' innovation behavior, if there is any.

2.4 Current Learning Webs

The author thoroughly investigated ten significant current learning webs in Taiwan to understand if they also noticed the above three concepts. The observation could be summarized as:

Table 1.

	Web Community	Culture	Cultivation
Yes	2	0	1
No	8	10	9

Most of learning webs were in radiation model, one way teaching, and without any culture consideration. This fact explained the emerging need and encouraged the author to develop an integrated web learning community environment.

3 Methodology

As an application research, four methods were employed:
1. Literature reviews.
2. Depth interviewing with experts whose major is in children education.
3. Web systems analysis and design. Four requirements had been defined, they were:
-Total Web-Based CAI: including structural learning materials, systematic learning achievement tests, scores database, users demographic database, parameters base, and analysis tools.
-Interactive learning navigation: guiding users how to solve problems with internet resources instead of telling them the answers.
-Collaborative classroom: creating an online virtue space for the moderator and users to allocate assignments, talk over problems, display output, and share knowledge.
-Community management: verifying the applications for moderators, recognizing the rights of them, providing tools and interfaces for moderators to prepare learning materials, tests, and other collaborative activities.
4. Field study on focus group: two primary schools, one in Gi-Lung City and the other in Tau-Yuan County, had been selected as focus group, interaction and users' feed back had been analyzed for further rigid experiments.

4 Results

4.1 Community Environment and User Interface

The web was named 'Gold Peach Web Community'. Gold Peach is a magic fruit in West Holy Mother's garden based on Chinese ancient legend. You could navigate the cloud and explore unknown world after eating the Peach. The sprit of scientific fiction is as keen as modern imagination.

Since Gold Peach also appears in the famous Chinese classic fiction ' The story of the venture tour to West' , we adopted and inherited the background, characters and plots from the story to create the cyber environment of the web as Figure3.

After logging in the community, the child users could play roles as Magic Monkey, Pig, Sandman, Dragon Horse or other genius etc. They could follow Master Monk to break in 81 forbidden area that were controlled by different monsters and demons. They could steal Gold Peach to surf the WWW to find out the answers for their questions. Or, they might join one of parties in Flower Island where they could chat or work out a task together.

Figure3. Gold Peach Entrance

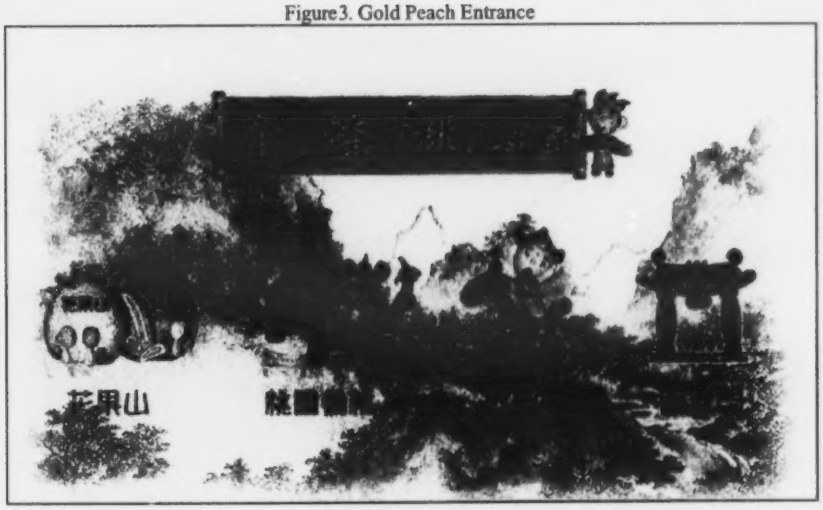


Figure4. Design Process

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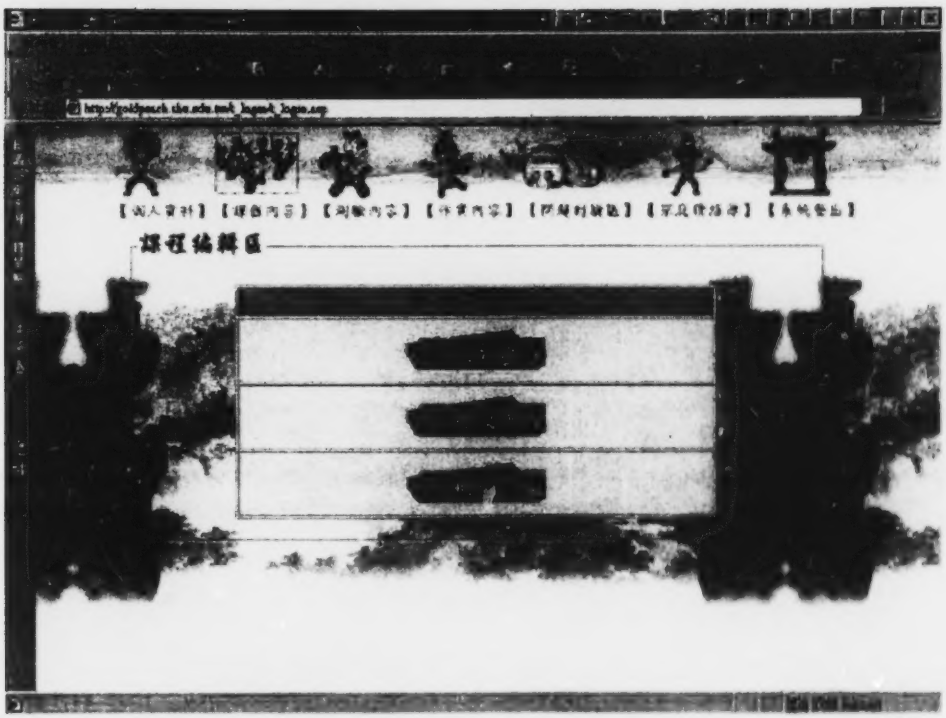

4.2 Interactive Learning Design Process

The moderator (teacher or expert) users could apply to be god or goddess in South Heaven Palace. After verification procedure, they would be authorized to be in charge a specific interest group to develop the learning interaction with child users.

With a easy, step-wise, and flexible tool (see
Figure4), they could plan their syllabus and learning units. It was easy to reorganize and modify chapters and sections.

There were multiple functions to support moderators to arrange test. They could use either closed-ended or open-ended questions, single option or multiple choices. They also wanted to design some hints for the users who did not pass the test. They could set links to the internet resources where buried the treasure of answers.

They could also direct a virtue seminar or assign a fieldwork. All participants could exchange their idea or experiences upon moderators' requests.

All closed-ended questions in tests would be graded automatically while moderators would mark the open-ended questions.

The users scores and evaluations would be computed and organized in database. A parameter framework would be derived from a certain amount of accumulative data later on. In the same time, a report of user's learning achievement would be prepared for use's parents through web connection. Parents also could reply their comments to the moderators.

5 Conclusions and Discussions

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5.1 Web Community: A progressive idea for learning environment

Web Community could be considered as a progressive idea for learning environment. It improved traditional one-way teaching and display and realized total peripheral participation and interaction.

The specification of 'Gold Peach Web Community' could be summarized as the following:
Developing interactive learning platform and environment where all community members could learn, solve problems, and share knowledge.

Consolidating learning contents that were combined primary schools' curricula with internet resources and information.

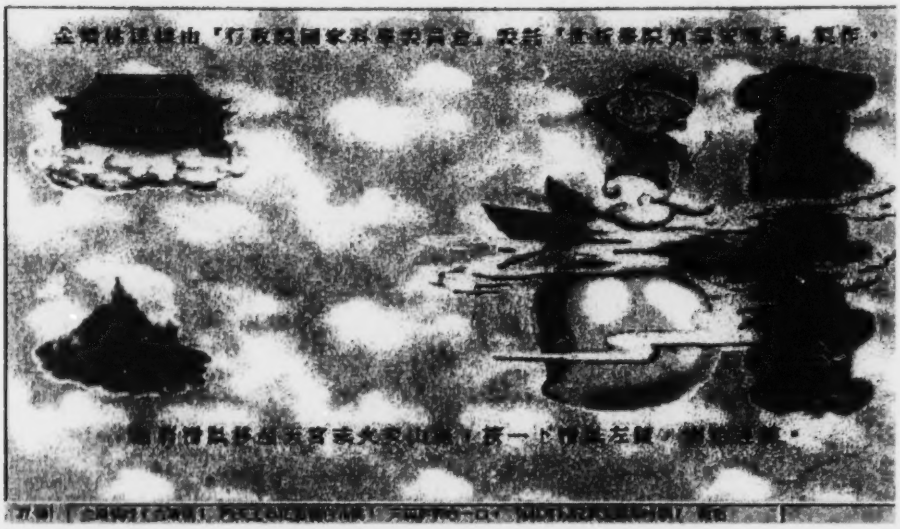
Reviewing and categorizing current information and webs that are suitable and interesting for children.

5.2 Culture: A deficiency, excess and integration trace

Three generations of the user interface were developed during last a few years. It revealed the introspection on seeking the cultural feature of web design.

Though the 'culture requirement' was highlighted according to the web developing strategy for the 1st generation, the implement was relatively unsuccessful. The artists in the project team were still lost in the long term Westernized training. The leading role, Magic Monkey, was cute, but lack of originality. The presentation of icons and background were inevitably under European shadow. (See Figure5)

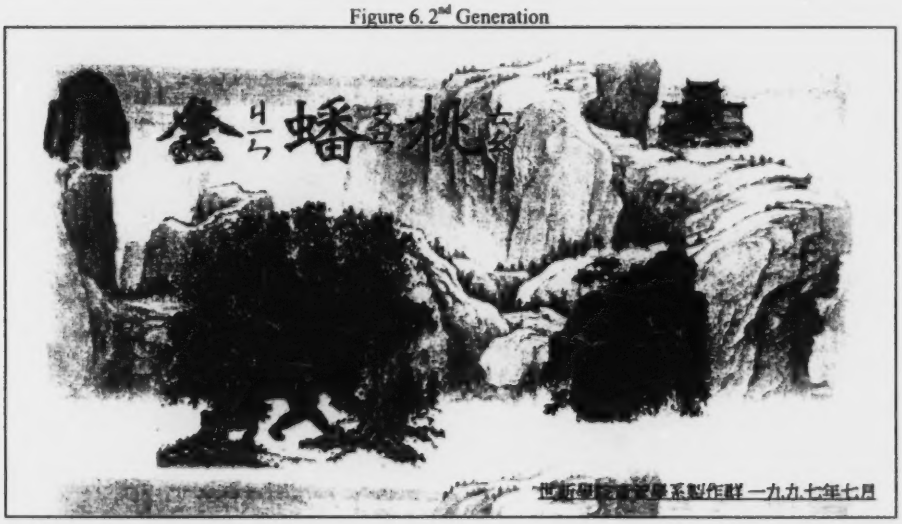
Figure5. 1st Generation



The effort on discovering lost tradition inspired the using of Chinese ink and calligraphy art to stylize the home page for the 2nd generation. The cultural specification was distinguished, however, the black-and-white idea was too abstract to attract children' s attention. (See Figure 6)

We did not find a balance between cultural skill and modern technique until the 3rd generation. We inherit the 3-D model of Chinese flour idol and the styling interest of folk drama to cerate cyber characters. The objects in the background were Chinese materials with modern simplified geometric outlines. The real culture should be a living idea that contented historic and current context. (See Figure3)

Figure 6. 2nd Generation



5.3 Cultivation: A ferment attempt

The result of this research 'Gold Peach Community' was expected to guide a new direction and a new method for children to develop their abilities of learning and problem solving under silent and positive cultivation.

The effort to discover the cultivation effect was still under ferment period. However, this research

investigated and accomplished some feedback mechanisms in the systems. They could detect and reveal possible cultivation effects by comparing users learning behaviors and achievement. Since cultivation is more likely a time series effect than a sudden change, the author suggests a large scaled and longitudinal experiment on this issue in the future studies.

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Integrating Electronic Mail Systems in Computer Literacy Instruction: Its Impacts on Student Attitudes and Interpersonal Relationships[1]

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The effectiveness of e-mail, as a supplementary instructional aid to computer literacy class and as a communication link between and among instructors and students, was explored in this study. More specifically, the effects of e-mail utilization in classrooms on student attitudes toward the instructor, the class and interpersonal relationships were the focus of the study. In total, sixty-eight prospect teachers enrolled in "Computers in Education" course participated in the study for a whole semester. Results from the study provided substantial evidence supporting e-mail's facilitative effects on student attitudes toward the instructor, the class as a whole, and other classmates.

Keywords: **Attitudes toward the class, Computer literacy instruction, E-mail, Interpersonal-relationships.**

1 Introduction

With unique characteristics like faster and asynchronous communications, greater flexibility for participant time management, improved receiver control and use of the message, and cost savings, etc. electronic mail (hereinafter named e-mail) is becoming more and more common in contemporary organizations [8, 12, 22, 24, 31, 33, 36]. In views of many of its advantageous features over conventional communication modes, e-mail has presented itself as a promising instructional and learning tool since its advertent.

Despite its potential value in variant educational settings, substantial evidence has come mostly from studies done in the areas of communication, literature and language learning [1-6, 9-21, 23, 25-30, 32]. For instance, Marttunen & Laurinen (1998) using e-mail as a forum for argumentation and debate supported the idea of incorporating the media for critical thinking and argumentation skills [19]. Whipp (1999) integrating e-mail discussion activity in an undergraduate methods course found that e-mail activity promoted reflection and joint interpretations of field experiences among participants [32].

Studies focusing on intercultural communications further stressed the multicultural learning opportunities e-mail engendered. For example, Cohen & Miyake's 1986 study showed that joint participation in the e-mail interaction across cultures could encourage multilingualism and awareness to other cultures [4]. Results from Ma's study (1993) indicated that students participating in the international e-mail communication tended to be more open of sharing information that provided them with subject and cultural knowledge [18]. Ruhe's endeavor (1998) in creating classroom e-mail exchanges among college

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preparatory English-as-a-Secondary students scattering around different continents again demonstrated that e-mail could be effective in teaching intercultural awareness [23]. Numerous scholars, on the other hand, focused on exploring and actualizing e-mail's educational potential for the teaching of writing and composition [1-3, 5-6, 10-11, 16, 25-30].

Though e-mail, as an instructional aid, has been claimed to provide students with greater access to faculty and peers, the impacts of e-mail systems on student attitudes toward the instructor, the class as a whole as well as interpersonal relationships severely fall short of empirical research basis at the present time. Thus, the present study focused on determining the value of e-mail communication in enhancing participant affect and social gains. The major purpose of the present study was to investigate the effectiveness of e-mail, one of the most accessible, convenient, and easy to use computer-mediated communications, on student learning outcomes. By incorporating e-mail into the instructional process, and inviting on-line communications both between and among instructors and students throughout the semester, the researcher expected to observe the differential effect e-mail has on student attitudes toward the instructor, the class and their classmates.

2 Methods

2.1 Participants and learning context

Two classes of students from "Computers in Education" course (N=68) participated in the study. The course was offered in 1999 semester year under a teacher preparation program in a National university in Southern Taiwan. The course was introductory and selective, aiming to strengthen prospect teachers' computer competency. Student self-introduction held at the first class session revealed that most students possessed only fundamental computer skills, had limited exposure to computer-mediated communication, and had not experienced e-mail utilization within class in the past. Additionally, as the course was offered during the Fall semester, most students were new to each other and had not taken the instructor's class before.

The study was conducted in a university computer laboratory with fifty computers designed for individual student learning. A Classroom Broadcast System was installed to network student workstations in the computer lab to further facilitate teaching and learning. During each class session, the instructor would give an overview of today's topics, explain and demonstrate the procedures involved in operating different computer applications and functions, which were interspersed with student hands-on practice. E-mail together with basic operation systems, word-processing, spreadsheet, computer-generated presentation using PowerPoint, and web-surfing techniques were taught by the same instructor in a one-semester two-credit course.

Two performance-type posttests were designed to assess student skills on operation systems, e-mail, word-processing and spreadsheet. A group-based final project of any topics of student choice was used for web-surfing and PowerPoint skills assessment.

2.2 Experimental design and treatment conditions

As most participants from both classes possessed fundamental computer skills and were acquainted to neither each other nor the instructor, a posttest-only experimental design was adopted in the study. To examine the potential effects of incorporating e-mail systems in a classroom setting, two participating classes were randomly assigned to different treatment conditions, namely, the e-mail utilization condition and the traditional condition. Prior to the commencement of the study, students were required to obtain a university e-mail account. A 2-hour class session was designated for e-mail instruction and practice. Procedures for sending, receiving, reading, responding, forwarding, printing, and deleting mails as well as e-mail features like address-book and attachment were explained, demonstrated and practiced in the class.

To examine the effectiveness of e-mail, as a supplementary instructional aid to computer literacy class and as a communication link between and among instructors and students, all instructional components and procedures were kept essentially the same except the way in which supplementary materials were disseminated to students and student assignments were handed in. In the e-mail utilization condition, instructors send out supplementary materials including weekly course outlines, additional reading materials, announcements, and computer-related news updates (e.g., newest computer virus) via e-mails at least two

days ahead of meeting time. Moreover, students were requested to hand in all their assignments/reports electronically and were encouraged to use it for future correspondence with the instructor, their teammates, and other classmates. As e-mail was treated as a supplementary channel to the class, no compulsory measures were taken to force students to use e-mail except those mentioned. Nevertheless, students were strongly encouraged by the instructor to log in the system at least once a week to check mails and print out any materials they deem useful. As mentioned previously, a group-based project gearing toward integrating Internet resources for any instructional topics of group choice was designed as the second evaluation component of the class, students were encouraged to take advantages of e-mail systems to communicate with their self-chosen teammates along the way. By opening up on-line communications both between and among instructors and students throughout the semester, the cultivation of elevated attitudes toward classmates, the instructor and the class was postulated.

In the traditional group, on the other hand, students would receive essentially the same supplementary materials in class and would hand in assignments directly to instructor, only that they were in hardcopy format. In other words, after the instruction on e-mail systems and functions, the instructor did not intentionally integrate e-mail utilization into the instructional process to further promote computer use. One last thing, performance-type posttests on e-mail ascertained that students in both treatment conditions mastered the skills.

2.3 Measures

A post-session self-report questionnaire administered individually at the last session of the class was used to collect data pertaining to the effects of integrating e-mail on student attitudes and interpersonal relationships. The 9-item "Class Evaluation" developed by the university was used for the measurement of student attitudes toward the instructor and the class as a whole. Sample items included, "the instructor was prepared and the instructional content was appropriate; the instructor was available to discuss academic matters with students both in and out of class and could explain things in a clear fashion; the instructor's attitude toward teaching was diligent, and the instructor was responsible and punctual." The 13-item "Perceptions Toward Teammates Scale," developed by Yu (1996-97), was used to test the hypothesis relevant to student perception toward their teammates [34]. Sample items included, "I am willing to work with my teammates again next time; I liked my teammates." Finally, the 11-item "Perceptions Toward Other Classmates Scale," developed by Yu (1996-97), was included to test the hypothesis relevant to student perceptual impressions of other classmates. Sample items included, "Other classmates helped me greatly with respect to my learning; other classmates were friendly." The internal consistency reliability (coefficient alpha) for student perceptions toward their teammates and other classmates was .92 and .86, respectively.

Each statement on the questionnaire was rated on a five-part discrete scale, with corresponding verbal descriptions ranging from "strongly disagree" through "disagree," "no-opinion/average," "agree," to "strongly agree." Each response received a weight of 1, 2, 3, 4, or 5, respectively. To counteract possible response-set tendencies, both positive and negative statements were included. Scoring on the negative statements was reversed so that negative and positive responses could be summed and averaged with higher scores reflecting more positive attitudes.

3 Results and discussion

Data were analyzed using the analysis of variance technique on student attitudes toward the instructor/class, their own teammates and other classmates. A .05 level of significance was adopted for use in this study. The means and standard deviation (SD) values for each of the dependent variables were listed in Table 1.

Results from t-tests showed significant differences between the two treatment conditions in student attitudes toward the instructor/class, $F(1, 66) = 2.898$, $p < .01$, and student attitudes toward other classmates, $F(1, 66) = 2.033$, $p < .05$. However, data analysis did not show significant differences between the two treatment conditions in student perception toward their own teammates, $F(1, 66) = 1.476$, $p > .05$. The results further showed that subjects in the e-mail utilization condition tended to rate the instructor/class and other classmates more positively than those in the traditional group.

Table 1: Descriptive Statistics of Different Treatment Conditions on Subject Attitudes Toward the Instructor/Class, Their Teammates, and Other Classmates

	Integrating E-mail Group (N=35) M (SD)	Traditional Group (N=33) M (SD)
Attitudes Toward the Instructor/Class	43.3605 (2.8042)	41.0303 (3.7800)
Perception Toward Their Teammates	57.7940 (6.2625)	55.3747 (7.3470)
Perception Toward Other Classmates	45.1944 (5.4867)	42.7273 (4.4880)

Data from after-session debriefings with participating students combined with sample e-mails both sent and received by students supported the idea of integrating e-mail systems into the learning process. While some students did take advantages of e-mail systems to ask academic-related questions (e.g., procedures for a specific application functions not covered in class, deadline for assignments, etc.) and/or send social greetings during holidays, the majority of e-mails transmitted were forwarding mails of variant topics ranging from health-related issues to jokes, novels and updated news in the technology world, etc. Many students pointed out that e-mail's distinct features like forwarding and address-book immensely facilitated interaction and information sharing among classmates and the instructor. Most students developed the habit of logging in the systems to retrieve e-mails along the way. Through increased interactions among the participants via receiving a wide array of articles and useful information forwarded from classmates and the instructor, mutual understanding, acceptance and bonding thus fostered. Thus, it was reasonably why students in e-mail conditions tended to view the instructor as better prepared, easier to locate, and other classmates as friendlier and more helpful.

Though the non-significant results in student attitude toward their own teammates was somewhat surprising at first, a closer look at e-mail use pattern among teammates shed some light onto the issue. E-mail was introduced into the learning environment in an attempt to facilitate group interaction within team-members; however, students in the e-mail treatment group rarely used this channel for online discussion and primarily as a last resort for scheduling purpose with their own teammates. As most group members sat closer to each other during the class and arranged meeting time for final project discussion right after class sessions, they didn't find e-mail especially useful in that aspect. As students did not use the technology for inner group communication except under very extreme situations, the fact that e-mail's integration into the learning environment did not significantly influence subjects' attitudes toward their teammates was understandable.

4 Conclusions

This study focused on examining whether incorporating e-mail into computer literacy classroom settings could positively influence student attitudes and interpersonal relationships. Results indicated that student attitudes toward the instructor/class and other classmates were positively influenced by this approach. The obtained results provided empirical evidence supporting the usefulness of e-mail as an aid for promoting out-of-classroom contacts of various types among faculty members and classmates, which, one way or the other, contributed to more positive attitudes.

Though e-mail might provide students with greater access to faculty and peers and seemed to enrich teacher/student interpersonal relationships in the present study, a word of suggestions for avant-courier was rendered. For e-mail to be effective as an alternative option for further two-way communication between teachers and students, all essential elements must be present. First, the important role "feedback" played during the process. Many students stressed that their willingness to continue having out-of-classroom contacts with instructors via e-mail was determined by the presence of the instructors' response in return. As Zaremba (1997) clearly pointed out "Without feedback, e-mail is likely to be less effective than it potentially could be. The quality of communication may be a function of the timeliness of feedback provided by the recipient." [35]. To create a bond of communication with students via e-mail, timeliness of feedback provided by the recipient would be an important task all participants need to attend to.

Secondly, for electronic communication to take effects, accessibility of essential hardware and software must be in place [22]. Some students mentioned specifically during the interview that limited access to computer hardware and network seriously prevented them from taking a full advantage of e-mail as a unique

communication tool. To ensure ongoing communications among participants electronically, interested implementers cannot ignore measures overcoming equipment and facility shortage.

Finally, opportunities for training and familiarization of the system for all parties would certainly facilitate the integration process. Extra time, care and possibly some incentives may be needed not only to get students accustomed to on-line message exchanges but also to have students appreciate e-mails' advantages especially during initial exchanges. Only when all the essential components as mentioned were in place, many of the potential impacts e-mail could have on the instructional settings like liberation of traditional roles associated with different parties, and humanitarian learning environments for all individuals would thus be actualized.

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Integrating Electronic Mail Systems in Computer Literacy Instruction: Its Impacts on Student Attitudes and Interpersonal Relationships[1]

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The effectiveness of e-mail, as a supplementary instructional aid to computer literacy class and as a communication link between and among instructors and students, was explored in this study. More specifically, the effects of e-mail utilization in classrooms on student attitudes toward the instructor, the class and interpersonal relationships were the focus of the study. In total, sixty-eight prospect teachers enrolled in "Computers in Education" course participated in the study for a whole semester. Results from the study provided substantial evidence supporting e-mail's facilitative effects on student attitudes toward the instructor, the class as a whole, and other classmates.

Keywords: **Attitudes toward the class, Computer literacy instruction, E-mail, Interpersonal-relationships.**

1 Introduction

With unique characteristics like faster and asynchronous communications, greater flexibility for participant time management, improved receiver control and use of the message, and cost savings, etc. electronic mail (hereinafter named e-mail) is becoming more and more common in contemporary organizations [8, 12, 22, 24, 31, 33, 36]. In views of many of its advantageous features over conventional communication modes, e-mail has presented itself as a promising instructional and learning tool since its advertent.

Despite its potential value in variant educational settings, substantial evidence has come mostly from studies done in the areas of communication, literature and language learning [1-6, 9-21, 23, 25-30, 32]. For instance, Marttunen & Laurinen (1998) using e-mail as a forum for argumentation and debate supported the idea of incorporating the media for critical thinking and argumentation skills [19]. Whipp (1999) integrating e-mail discussion activity in an undergraduate methods course found that e-mail activity promoted reflection and joint interpretations of field experiences among participants [32].

Studies focusing on intercultural communications further stressed the multicultural learning opportunities e-mail engendered. For example, Cohen & Miyake's 1986 study showed that joint participation in the e-mail interaction across cultures could encourage multilingualism and awareness to other cultures [4]. Results from Ma's study (1993) indicated that students participating in the international e-mail communication tended to be more open of sharing information that provided them with subject and cultural knowledge [18]. Ruhe's endeavor (1998) in creating classroom e-mail exchanges among college

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preparatory English-as-a-Secondary students scattering around different continents again demonstrated that e-mail could be effective in teaching intercultural awareness [23]. Numerous scholars, on the other hand, focused on exploring and actualizing e-mail's educational potential for the teaching of writing and composition [1-3, 5-6, 10-11, 16, 25-30].

Though e-mail, as an instructional aid, has been claimed to provide students with greater access to faculty and peers, the impacts of e-mail systems on student attitudes toward the instructor, the class as a whole as well as interpersonal relationships severely fall short of empirical research basis at the present time. Thus, the present study focused on determining the value of e-mail communication in enhancing participant affect and social gains. The major purpose of the present study was to investigate the effectiveness of e-mail, one of the most accessible, convenient, and easy to use computer-mediated communications, on student learning outcomes. By incorporating e-mail into the instructional process, and inviting on-line communications both between and among instructors and students throughout the semester, the researcher expected to observe the differential effect e-mail has on student attitudes toward the instructor, the class and their classmates.

2 Methods

2.1 Participants and learning context

Two classes of students from "Computers in Education" course (N=68) participated in the study. The course was offered in 1999 semester year under a teacher preparation program in a National university in Southern Taiwan. The course was introductory and selective, aiming to strengthen prospect teachers' computer competency. Student self-introduction held at the first class session revealed that most students possessed only fundamental computer skills, had limited exposure to computer-mediated communication, and had not experienced e-mail utilization within class in the past. Additionally, as the course was offered during the Fall semester, most students were new to each other and had not taken the instructor's class before.

The study was conducted in a university computer laboratory with fifty computers designed for individual student learning. A Classroom Broadcast System was installed to network student workstations in the computer lab to further facilitate teaching and learning. During each class session, the instructor would give an overview of today's topics, explain and demonstrate the procedures involved in operating different computer applications and functions, which were interspersed with student hands-on practice. E-mail together with basic operation systems, word-processing, spreadsheet, computer-generated presentation using PowerPoint, and web-surfing techniques were taught by the same instructor in a one-semester two-credit course.

Two performance-type posttests were designed to assess student skills on operation systems, e-mail, word-processing and spreadsheet. A group-based final project of any topics of student choice was used for web-surfing and PowerPoint skills assessment.

2.2 Experimental design and treatment conditions

As most participants from both classes possessed fundamental computer skills and were acquainted to neither each other nor the instructor, a posttest-only experimental design was adopted in the study. To examine the potential effects of incorporating e-mail systems in a classroom setting, two participating classes were randomly assigned to different treatment conditions, namely, the e-mail utilization condition and the traditional condition. Prior to the commencement of the study, students were required to obtain a university e-mail account. A 2-hour class session was designated for e-mail instruction and practice. Procedures for sending, receiving, reading, responding, forwarding, printing, and deleting mails as well as e-mail features like address-book and attachment were explained, demonstrated and practiced in the class.

To examine the effectiveness of e-mail, as a supplementary instructional aid to computer literacy class and as a communication link between and among instructors and students, all instructional components and procedures were kept essentially the same except the way in which supplementary materials were disseminated to students and student assignments were handed in. In the e-mail utilization condition, instructors send out supplementary materials including weekly course outlines, additional reading materials, announcements, and computer-related news updates (e.g., newest computer virus) via e-mails at least two

days ahead of meeting time. Moreover, students were requested to hand in all their assignments/reports electronically and were encouraged to use it for future correspondence with the instructor, their teammates, and other classmates. As e-mail was treated as a supplementary channel to the class, no compulsory measures were taken to force students to use e-mail except those mentioned. Nevertheless, students were strongly encouraged by the instructor to log in the system at least once a week to check mails and print out any materials they deem useful. As mentioned previously, a group-based project gearing toward integrating Internet resources for any instructional topics of group choice was designed as the second evaluation component of the class, students were encouraged to take advantages of e-mail systems to communicate with their self-chosen teammates along the way. By opening up on-line communications both between and among instructors and students throughout the semester, the cultivation of elevated attitudes toward classmates, the instructor and the class was postulated.

In the traditional group, on the other hand, students would receive essentially the same supplementary materials in class and would hand in assignments directly to instructor, only that they were in hardcopy format. In other words, after the instruction on e-mail systems and functions, the instructor did not intentionally integrate e-mail utilization into the instructional process to further promote computer use. One last thing, performance-type posttests on e-mail ascertained that students in both treatment conditions mastered the skills.

2.3 Measures

A post-session self-report questionnaire administered individually at the last session of the class was used to collect data pertaining to the effects of integrating e-mail on student attitudes and interpersonal relationships. The 9-item "Class Evaluation" developed by the university was used for the measurement of student attitudes toward the instructor and the class as a whole. Sample items included, "the instructor was prepared and the instructional content was appropriate; the instructor was available to discuss academic matters with students both in and out of class and could explain things in a clear fashion; the instructor's attitude toward teaching was diligent, and the instructor was responsible and punctual." The 13-item "Perceptions Toward Teammates Scale," developed by Yu (1996-97), was used to test the hypothesis relevant to student perception toward their teammates [34]. Sample items included, "I am willing to work with my teammates again next time; I liked my teammates." Finally, the 11-item "Perceptions Toward Other Classmates Scale," developed by Yu (1996-97), was included to test the hypothesis relevant to student perceptual impressions of other classmates. Sample items included, "Other classmates helped me greatly with respect to my learning; other classmates were friendly." The internal consistency reliability (coefficient alpha) for student perceptions toward their teammates and other classmates was .92 and .86, respectively.

Each statement on the questionnaire was rated on a five-part discrete scale, with corresponding verbal descriptions ranging from "strongly disagree" through "disagree," "no-opinion/average," "agree," to "strongly agree." Each response received a weight of 1, 2, 3, 4, or 5, respectively. To counteract possible response-set tendencies, both positive and negative statements were included. Scoring on the negative statements was reversed so that negative and positive responses could be summed and averaged with higher scores reflecting more positive attitudes.

3 Results and discussion

Data were analyzed using the analysis of variance technique on student attitudes toward the instructor/class, their own teammates and other classmates. A .05 level of significance was adopted for use in this study. The means and standard deviation (SD) values for each of the dependent variables were listed in Table 1.

Results from t-tests showed significant differences between the two treatment conditions in student attitudes toward the instructor/class, $F(1, 66) = 2.898$, $p < .01$, and student attitudes toward other classmates, $F(1, 66) = 2.033$, $p < .05$. However, data analysis did not show significant differences between the two treatment conditions in student perception toward their own teammates, $F(1, 66) = 1.476$, $p > .05$. The results further showed that subjects in the e-mail utilization condition tended to rate the instructor/class and other classmates more positively than those in the traditional group.

Table 1: Descriptive Statistics of Different Treatment Conditions on Subject Attitudes Toward the Instructor/Class, Their Teammates, and Other Classmates

	Integrating E-mail Group (N=35) M (SD)	Traditional Group (N=33) M (SD)
Attitudes Toward the Instructor/Class	43.3605 (2.8042)	41.0303 (3.7800)
Perception Toward Their Teammates	57.7940 (6.2625)	55.3747 (7.3470)
Perception Toward Other Classmates	45.1944 (5.4867)	42.7273 (4.4880)

Data from after-session debriefings with participating students combined with sample e-mails both sent and received by students supported the idea of integrating e-mail systems into the learning process. While some students did take advantages of e-mail systems to ask academic-related questions (e.g., procedures for a specific application functions not covered in class, deadline for assignments, etc.) and/or send social greetings during holidays, the majority of e-mails transmitted were forwarding mails of variant topics ranging from health-related issues to jokes, novels and updated news in the technology world, etc. Many students pointed out that e-mail's distinct features like forwarding and address-book immensely facilitated interaction and information sharing among classmates and the instructor. Most students developed the habit of logging in the systems to retrieve e-mails along the way. Through increased interactions among the participants via receiving a wide array of articles and useful information forwarded from classmates and the instructor, mutual understanding, acceptance and bonding thus fostered. Thus, it was reasonably why students in e-mail conditions tended to view the instructor as better prepared, easier to locate, and other classmates as friendlier and more helpful.

Though the non-significant results in student attitude toward their own teammates was somewhat surprising at first, a closer look at e-mail use pattern among teammates shed some light onto the issue. E-mail was introduced into the learning environment in an attempt to facilitate group interaction within team-members; however, students in the e-mail treatment group rarely used this channel for online discussion and primarily as a last resort for scheduling purpose with their own teammates. As most group members sat closer to each other during the class and arranged meeting time for final project discussion right after class sessions, they didn't find e-mail especially useful in that aspect. As students did not use the technology for inner group communication except under very extreme situations, the fact that e-mail's integration into the learning environment did not significantly influence subjects' attitudes toward their teammates was understandable.

4 Conclusions

This study focused on examining whether incorporating e-mail into computer literacy classroom settings could positively influence student attitudes and interpersonal relationships. Results indicated that student attitudes toward the instructor/class and other classmates were positively influenced by this approach. The obtained results provided empirical evidence supporting the usefulness of e-mail as an aid for promoting out-of-classroom contacts of various types among faculty members and classmates, which, one way or the other, contributed to more positive attitudes.

Though e-mail might provide students with greater access to faculty and peers and seemed to enrich teacher/student interpersonal relationships in the present study, a word of suggestions for avant-courier was rendered. For e-mail to be effective as an alternative option for further two-way communication between teachers and students, all essential elements must be present. First, the important role "feedback" played during the process. Many students stressed that their willingness to continue having out-of-classroom contacts with instructors via e-mail was determined by the presence of the instructors' response in return. As Zaremba (1997) clearly pointed out "Without feedback, e-mail is likely to be less effective than it potentially could be. The quality of communication may be a function of the timeliness of feedback provided by the recipient." [35]. To create a bond of communication with students via e-mail, timeliness of feedback provided by the recipient would be an important task all participants need to attend to.

Secondly, for electronic communication to take effects, accessibility of essential hardware and software must be in place [22]. Some students mentioned specifically during the interview that limited access to computer hardware and network seriously prevented them from taking a full advantage of e-mail as a unique

communication tool. To ensure ongoing communications among participants electronically, interested implementers cannot ignore measures overcoming equipment and facility shortage.

Finally, opportunities for training and familiarization of the system for all parties would certainly facilitate the integration process. Extra time, care and possibly some incentives may be needed not only to get students accustomed to on-line message exchanges but also to have students appreciate e-mails' advantages especially during initial exchanges. Only when all the essential components as mentioned were in place, many of the potential impacts e-mail could have on the instructional settings like liberation of traditional roles associated with different parties, and humanitarian learning environments for all individuals would thus be actualized.

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[20] Rankin, W., "Increasing the communicative competence of foreign language students through the LF

Internet Video on Demand System of Classroom Teaching Cases

- Building "RAPSODY": An Intelligent Media-Oriented Remote Educational System for Self-Learning Support -

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Our study aims to accumulate information for teachers, about established teaching methodologies and techniques. For the purpose of our study, we construct a searching system for lesson example videos, and we develop an environment for facilitating the usage of our example videos, and for encouraging teachers' collaboration. Concretely, we focus on the domain of the new subject introduced in the Japanese curriculum, called "Information Education". In this paper, we describe the details of our video searching system, the design of the database tables, and we show an example of system operation.

Keywords: **Information Education, Teacher Education, Distance Learning, VOD, Rapsody**

1 Introduction

In now-a-days advanced information society, the demands about teachers' competence are high and diverse. Concretely, teachers are required to posses on one hand curriculum development ability, learning environment design ability, group learning, individual learning, simultaneous learning, and on the other hand the previous abilities should be supported by class practice ability, observation and evaluation ability, and last but not least, the ability to connect the textbook's world and the real world.

It is difficult to raise and form this complex set of abilities, with the help of only the presently available education and training methodology for teachers. Therefore, the necessity emerged [1] to examine the feasibility of a new systematic approach, for supporting the teachers' literacy progress, by building on their natural talents/ and abilities, and expanding these to reach the required width and breadth.

The information technology science is offering the tools for the development of an environment supporting the teachers' endowment progress. The knowledge concerning the teachers' education contents and methods is stored as multimedia information, in the form of pictures, videos and sound tracks. Moreover, by using the network environment, it is possible to make use of all resources over the net, without any constraints or restrictions of time and/or geographical location.

With this goal in mind, we are researching the development of an integrative distance education training system for supporting teachers' self-training, called RAPSODY (Remote and Adaptive System of Oriented Dynamic Teaching/Learning). Up to now, the availability of video records and guidance plans about lessons was limited to education training centers or universities, etc. The present research intends to make the information on educational activities and practices public, and aims at joint usage and re-usage of teachers' self-learning and self-training methodologies and tools. Concretely, we develop a retrieval system based on dialogue patterns, by using a database of lesson videos.In order to jointly use the information in the distributed environment, or to be able to re-use it, we implemented a Video On Demand (VOD) system. The (teacher) user can control/manage the specification and stop/suspension of

the regeneration point for the distributed VOD.

The main purpose of our research is therefore to propose a distance-learning environment on the Internet, for improving the teachers' practical abilities. In this paper, we describe the video on demand system developed until now, the indexing method of the classroom teaching movie example database, the system's functions and the system's evaluation.

2 The outline of the system

2.1 The structure of the system

Fig. 1 shows the structure of the search system. The system is built of the following three parts:

- Web browser;
- Lesson video example database;
- Video distribution server.

The web browser has the role of the user interface. The search/retrieval mechanism searches the lesson example video database via three types of relational database files.

The video distribution server stores the lesson scenes' videos. The video distribution server performs the VOD function at the users' requests. The search functions performed for the user are of the following two types.

- Keyword Search
- Feature Oriented Search

The Keyword Search (fig. 1,) takes place as explained below.

a-1) The user designates the search conditions.
b-1) The search mechanism compares the search conditions input by the user, with the available class example video database.
c-1) The search mechanism extracts the record(s) matching the searching conditions.
d-1) The result is displayed as the search result.

The Feature Oriented Search process (fig. 1,) is done as shown in the following.

a-2) The system dialogue mechanism enquires about the video characteristics/features desired by the user.
b-2) The user can answer to the system's enquiry vaguely [2].
c-2) The decision making table (showed later on in table 6), obtained from the user, is the basis for the evaluation of the specific search conditions. The gathered search conditions are passed over to the search mechanism of the database.
d-2) The database search mechanism compares the search conditions resulting from the evaluation with the lesson example videos contained in the database.
e-2) This result is displayed as the search result.

The search result is formatted as an URL list that is shown to the user. These URLs perform the function of linking the search result and the actual videos on the VOD server. The (teacher) user chooses the URL that s/he wants to refer (Fig. 1,).When the URL is chosen, the VOD client software, embedded via the Web browser plug-in, starts, and the video playback begins.

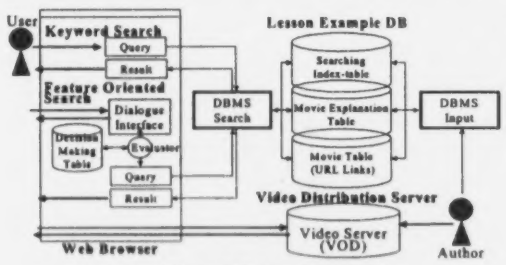

Figure 2 Sstem Organization

3. Database structure

3.1 Lesson (unit) database

The following three relational database files define the video lesson database.

- Searching Index File
- Movie Explanation File
- Movie File

In the following, we will explain in detail each database file type.

3.2 Searching Index File

The Searching Index File results from the comparison of the video database with the search items. The search items are organized in items for the Keyword Search and items for the Feature Oriented Search. In table 1, we show the Searching Index File for the Keyword Search, and in table 2, the Searching Index File for the Feature Oriented Search.

For the Keyword Search, the search conditions are given directly by the user. The Searching Index File slots are "lesson name (unit)", "learning contents (subunit)", "used information equipment/machinery/device(s)", "used tool(s) application(s)" and "class viewpoint".

In the Feature Oriented Search, the system generates the search conditions, based on the information obtained from the user. The Searching Index File (Feature Oriented Search) employs comparison of the extracted search conditions and the database, depending on the dialogue with the user. The slots of the Searching Index File for the Feature Oriented Search mechanism are "teacher activity " and "student activity ".

Table 1 Searching Index File (Keyword Search)

index frame database .basic search key

record fields	value type
ID (primary key)	*numerical value type*
lesson name (unit)	*text type (menu selection)*
learning contents (subunit)	*text type (menu selection)*
used information equipment/ machinery/ device(s)	*text type (menu selection)*
used tool(s) application(s)	*text type (menu selection)*
class viewpoint	*text type (menu selection)*

Table 2 Searching Index File (Feature Oriented Search)

index frame database .feature search key

record fields	value type
ID (primary key)	*numerical value type*
teacher activity	*text type (menu selection)*
student activity	*text type (menu selection)*

3.3 Movie Explanation File

Table 3 shows the contents of the Movie Explanation File, regarding the movie features. When the user is about to commence the lesson, the points, which need his/her attention, are explained via the contents of the Movie Explanation File. These explanations are used when displaying the search results.

Table 3 movie explanation file

movie feature description .video feature information)

record fields	value type
camera angle	*text type (menu selection)*
equipment existence	*text type (menu selection)*
equipment usage	*text type (menu selection)*
number of teachers	*text type (menu selection)*
teachers' movements	*text type (menu selection)*
existence learning supporter(s)	*text type (menu selection)*

number of students	*text type (menu selection)*
students' movements	*text type (menu selection)*
existence of a central student	*text type (menu selection)*

The explanation information in the Movie Explanation File (table 4) resumes the lesson scenes compiled by the video registrants, and the information on how the checkpoints, necessary for the lesson, were estimated. The slot of table 4 called "teacher's aim", corresponds, for instance, to the classification 8 presented later on in table 7.The "checkpoints 1 to 3" express the free description of the image, from the points of view shown below.

Checkpoint 1 the movie preconditions to be considered;

Checkpoint 2 what should be extracted/ understood from the current movie;

Checkpoint 3 the necessary forecast of the movie's following development.

Table explanation file

4 movie

movie explanation database

record fields	value type
ID (primary key)	*numerical value type*
teacher's aim	*text type (menu selection)*
checkpoint 1	*text type (item description · within 100 characters)*
checkpoint 2	*text type (item description · within 100 characters)*
checkpoint 3	*text type (item description · within 100 characters)*

3.4 Movie File

Table 5 shows the Movie File. The Movie File contains pointers to the real videos. The VOD server houses the real videos. Table 5 contains the Movie File slots called "thumbnail picture (still picture)", "previous movie", "movie URL (movie file name)", and "next movie".

Table 5 movie file

movie database

record fields	value type
ID (primary key)	*numerical value type*
thumbnail picture (still picture)	*text type (still movie file name)*
previous movie	*text type (URL type input)*
movie URL (movie file name)	*text type (URL type input)*
next movie	*text type (URL type input)*

For the discrete movie time-series {P(t)}, the following relationship exists:
$[P(t-1),P(t),P(t+1)]$ = [previous movie, movie URL, next movie]; $P(t=0)$ = {still picture}; where t is the time.

4 The system's behavior

Figure 2 shows the search conditions input interface (for Keyword Search). Figure 3 shows the search result display interface. After the (teacher) user specifies the conditions for the desired video search via the search conditions input interface, the search starts. The result of this is displayed in the search result display interface [3] [4]. This interface shows the value of the slots called " still picture", "lesson contents (subunit)", "teacher's aim", "checkpoints", "teachers' activity" and "students' activity". The "still picture" can be seen in figure 3 (). Next to being a significant snapshot of the lesson video, the still picture has also the role of a pointer to the real video (a link to the VOD video file), so describes the URL (figure 3,). By clicking on the still picture, the video starts (figure 3,). The "teacher's aim" (fig. 3,) and "checkpoints" (fig. 3,) are, as mentioned before, the most important information for image explanation. The figure also presents the (teacher) user with help/support information about other items and record fields.

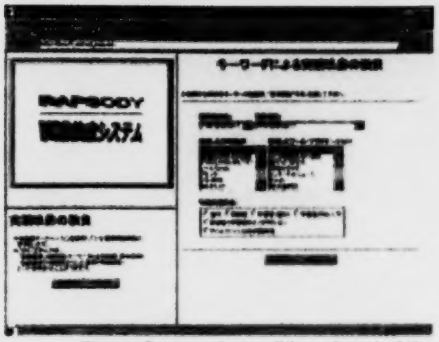

Figure 2 search conditions input picture

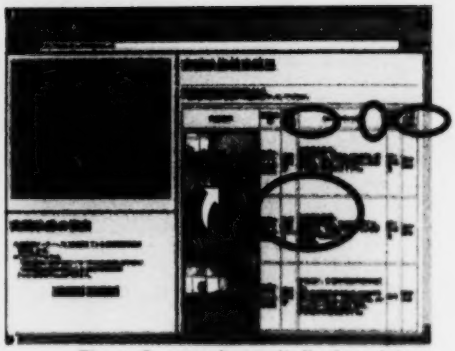

Figure 3 search result display picture

5 Conclusions

We construct a searching system for lesson example videos, and we develop an environment for facilitating the usage of our example videos, and for encouraging teachers' collaboration. Concretely, we focus on the domain of the new subject introduced in the Japanese curriculum, called "Information Education".We have presented in this paper the summary of the video search VOD system we have developed, moreover, we have shown the database organization and the system's behavior.As for the future tasks and research, we are planning to investigate about building a flexible key for the video search mechanism. We are studying at present the dialogue mechanism, with the immediate goal of using the search result's negative feedback information to the user's request, to serve as a new search key.

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Learner Control in Technology-mediated Learning within a Constructivist Model

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This paper explores current strategies on learner control within a technology-mediated learning environment, with a special emphasis on constructivism as the underlying learning theory. An adaptive learning model, based on constructivism is presented. The model addresses the issues of learner control and its implementation within a technology-mediated learning environment. The model's major components: Learner module, Designers module, User Control Manager module, Cyber Classroom module and the Analyser module are outlined and analysed. The aim of the model is to offer an adaptive learning system that caters for different types of learners and learning styles, with an especial emphasis on learner control. The model empowers the learners and provides them with the means for constructing and re-constructing knowledge at their own pace within a constructivist framework that is learner centred and flexible. We propose a system that is dynamic and merges the capacity to deliver educational material with the ability to analyse learners performance, based on navigational patterns and results, and system performance in order to either advise and guide the learner or to modify learning materials or their presentation.

Keywords: **Learner Control, Technology-mediated Learning, Constructivism, Technology-mediated Adaptive Learning Model.**

1 Introduction

Technology has impacted greatly on education. Since the introduction of technology, new delivery methods, as well as new challenges, have emerged. One of the most important delivery methods introduced has been flexible delivery or flexible learning as it is now preferably called. Flexible learning is learning that can be achieved at your own pace and independently of time and place. Several technology-mediated approaches, for example, Web Based Instruction (WBI) and Competency Based Instruction (CBI), have been used to provide the flexibility required to deliver flexible learning.

Technology-mediated learning is versatile. It can be used as the only means to deliver education or as an aid to traditional up-front teaching. Although technology has been embraced by education, there are areas of concern over its use, or more precisely, over its misuse. Areas of concern include: access to the medium, measurement of students learning, testing the validity of the Internet as an instructional medium and the cost of producing technology-based learning materials (Rickard, 1999; Eckert *et al.*, 1997). Selwyn (1996) points out that the Internet can become a trap for both teachers and students as it can go from the '*tool to the toy*' in education if its use is not properly guided and monitored. Phillips (1980) also expresses concern about the quality of on-line materials on the Internet. In spite of these issues the proliferation of courses designed and developed for a technology-mediated environment continues to increase.

This paper explores current trends on technology-mediated learning environments with an especial emphasis on learner control. The paper also proposes an adaptive learning model based on constructivism. The model addresses the issue of learner control and its implementation within a technology-mediated learning environment.

2 Technology and learning control

A technology-mediated environment offers the learner a number of choices and alternatives that were inconceivable in a traditional educational setting. Traditional education, both on-campus and distance learning, is highly structured, teacher centred, mostly one-way communication and directed to passive learners. In contrast, technology-mediated learning, within a constructivist approach, can be learner centred, unstructured to suit the learner's individual learning needs and context-based. It also allows the learner to take control of the learning process, promotes social discourse and collaboration and contributes to the personal growth of the learner.

2.1 Learner Control in Technology-mediated Learning

The definition of *learner control* often appears to be elusive. In its broadest sense, learner control refers to the level of self-determination that the learner has in making decisions about his/her learning (Doherty, 1998). Learner control is often being addressed in combination with other factors. For example, learner control and attitude towards the technology-based system used (Ivanoff and Clarke, 1996; Mitra, 1997) and learner control and epistemic beliefs (Jacobson, *et al.*, 1996). Learner control, within the scope of this paper, refers to the degree of autonomy that learners have in organising, pacing, sequencing and using the available learning resources. That is, the ability and power of adapting the technology-mediated environment to suit their individual specific learning needs. Control over their learning direction and pace is made possible by the many alternatives and choices that a technology-mediated learning system offers the learner (Bagui, 1998). The level of control that the learner needs to exert over the learning environment is not constant over time. Learners will engage in different levels of control depending on their individual learning style (Rasmusen and Davidson-Shivers, 1998), prior knowledge of the material or related material (Fitzgerald and Semrau, 1998), attitude towards information technology (Ivanoff and Clarke, 1996; Mitra, 1997) and past experience, initiative, intellectual and social maturity, metacognitive proficiency, and insights (Ewing *et al.*, 1998).

2.2 The role of the teacher in Technology-mediated Learning

Frank Wydra anticipated a learning environment in which the teacher's role focus changed from delivering instruction to designing the instruction (Wydra, 1980). By the hand of technology we may transform the teacher from the *"sage on stage"* to the *"guide at the side"* (Andrews, 1997). Within a technology-mediated learning environment, the educator's role, far from becoming redundant, metamorphoses into a more challenging and active one. The educator becomes the leader, designer and manager of the learning environment (Doherty, 1998). Other vital functions are initiating the learning process; supporting, encouraging and motivating the learner and mediating between the learner, the technology and the resources (*Ewing et al., 1998*).

The new role of the teacher, in technology-mediated learning, is a very demanding one. *Ewing et al.*, (1998) emphasise the great deal of effort that goes into planning and preparing technology-mediated learning materials and environments. The design and development of multimedia teaching material, especially for distance education, is a time-consuming process. For one hour of CBT software approximately 200 hours of development time are required (Kawalek, 1995). The educator's role does not stop after the planning, designing and preparation of the technology-based materials. It must also facilitate the learning, monitor learners' progress and evaluate the performance of the system, the learners' and his/her own in order to further improve the system. *"The need for the teacher does not go away"* in a technology-mediated environment with emphasis on learner control (Andrews, 1997).

3 Constructivism

The introduction of technology-mediated learning has called for a revision of learning strategies.

Constructivism is gaining momentum and has been heralded as the most appropriate learning theory for the technological classroom. Constructivism was introduced by Piaget's and Vygotsky's learning theories. Piaget's learning theory involves two cognitive stages: assimilation and accommodation (West *et al.*, 1991). During the assimilation stage the learner attempts to fit the environment with existing mental schemata. The accommodation stage is reached when the learner is confronted with a new experience, for which no schemata exists, or one exists but does not conform to the new experience. As a result, equilibrium occurs when, through an alternate process of assimilation and accommodation, the learner achieves cognitive stability. Externally in-coming experiences find a corresponding mental schemata and the learner is aware of this fact. In order to achieve high-level cognition the learner must be aware that learning has indeed occurred. Otherwise, learning will stop at the behaviourist level where it is ascertained by an external party, usually the teacher, or in the case of a technology-mediated environment by a computer program.

Vygotsky's learning theory differs from Piaget's in that he sees learning taking place within a social and cultural context. He argues that social interaction affects the way the learner sees the world. That is, it contributes to the way the learner constructs his/her schemata. Therefore, the quality of the learning will be determined by the quality of the social interactions or what Vygotsky terms *zone of proximal development* (Oliver, *et al.*, 1997).

In a learning environment the cultural and social interactions translate to interactions between teachers and peers. Within this collaborative learning environment the teacher becomes the facilitator of learning. The facilitator's role should be to design, promote and guide the learning but not to enforce it as learning is an individual process. Knowledge in this environment is socially constructed and has no absolute value but a socially agreed value.

4 The proposed learning model

The aim of the proposed model is to offer an adaptive learning system that caters for different types of learners and learning styles with an especial emphasis on learner control. The proposed model operates within a constructivist approach to learning (Ewing, *et al.*,) based on the following points:

1. **All learners are different**
2. **Learning is individual to each learner**
3. **A learner can learn at different speed levels in different situations**
4. **A learner can engage in different learning strategies simultaneously**
5. **Learners learn best with a context**
6. **Learners construct and re-construct knowledge as they seek to understand and explain their environment**

4.1 Proposed model learning variables and controls

The concepts of learner individuality and learner control are essential to constructivism. Table 1 below depicts the main variables involved in the proposed model in relation to learning control and learners' choices and options.

VARIABLES	CONTROLS	
	INSTRUCTOR	LEARNER
Learning Objectives	Overall	
Amount of information provided	Overall	
Amount of information used **Addition/removal of material**		Desirable
Material appearance and mode		Desirable
Pacing, time	(When necessary)	Desirable
Sequencing	(When necessary)	Desirable
Place, location		Desirable
Monitoring learners' individual progress	Overall	
Interaction and collaboration	Shared	Shared
Assessment	Overall	

Table 1. Control Variables and Controllers

The term ***desirable***, rather than ***overall***, is used in the learner control column because the proposed model's aim is to empower learners not to force them to take control. For example, a learner that possesses prior knowledge of a topic is more likely to exercise control over his/her learning than a novice learner is. The second is more likely to follow a linear approach to learning until he/she too acquires prior knowledge.

Learning objectives
Learning objectives within the model are explicit, clearly specified and achievable. The acquisition of non-anticipated learning objectives is possible within the system, especially, when the learner accesses more information that is required to complete a task. This is a positive feature of the model as far as the specified learning objectives have been reached.

Amount of information provided and used
The system contains all the information necessary to achieve the specified learning objectives or provides references to acquire it. However, the learner controls the amount of information that is actually used. A learner can discard a particular learning material piece in favour of another, which has been acquired from external sources, just because is easier to understand or is visually more appealing. Learners' performance can be improved by designing materials that can be adapted to satisfy different learning styles (Rasmussen and Davidson-Shivers, 1998).

Learning material appearance and mode
A genuinely adaptive technology-mediated learning system must allow learners to customise the appearance and mode of the material displayed. This may include: changing background and text colours and choosing between text, graphics, audio and video modes.

Pacing and timing
The learner has the autonomy of pacing his/her learning and scheduling his/her study time. However, in some instances this has to fit within the general time-frame allocated to the course or subject. The designer controls the general time-frame, if one exists.

Sequencing
Learning materials must be accessed in the order that most benefits the learners' learning style. The model is able to cope with the demands of linear as well as non-linear approaches to learning. Figure 1 displays an example of the progression or navigation path of a learner who prefers to be guided by the system. '*Learner 1*' uses all the material provided and in the order provided until she encounters difficulties and seeks the help of an instructor or other learners. Then, revises the previous lesson and again continues with the linear path provided. In contrast, '*Learner 2*' feels confident enough to discard material provided and adds material from external sources. Both learners achieve the corresponding learning objectives through the use of different learning strategies. Beginners often benefit from having a structured learning path (Eaton, 1996). A graphical representation or map of the entire unit or lesson must be made available to the learners to guide their navigation decisions (Barba, 1993).

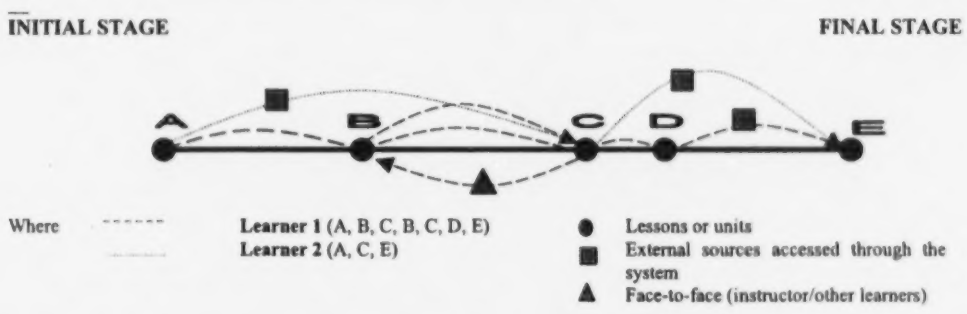


Figure 1. Learning Sequence Patterns – Linear and Non-linear

Learners must be free to use forward and backward navigation through the system as long as it does not compromise the learning itself. For example, if the completion of a task is the pre-requisite for another,

allowing the learner to move onto a task for which a pre-requisite has not been completed might result in a waste of time and unnecessary added frustration for the learner. For example, moving into algebra without knowing how to multiply.

Place and location
Technology-mediated learning offers the possibility of accessing and using learning materials at different locations. Using the proposed model, learners can now study at home, at appropriately equipped learning centres or at traditional classrooms.

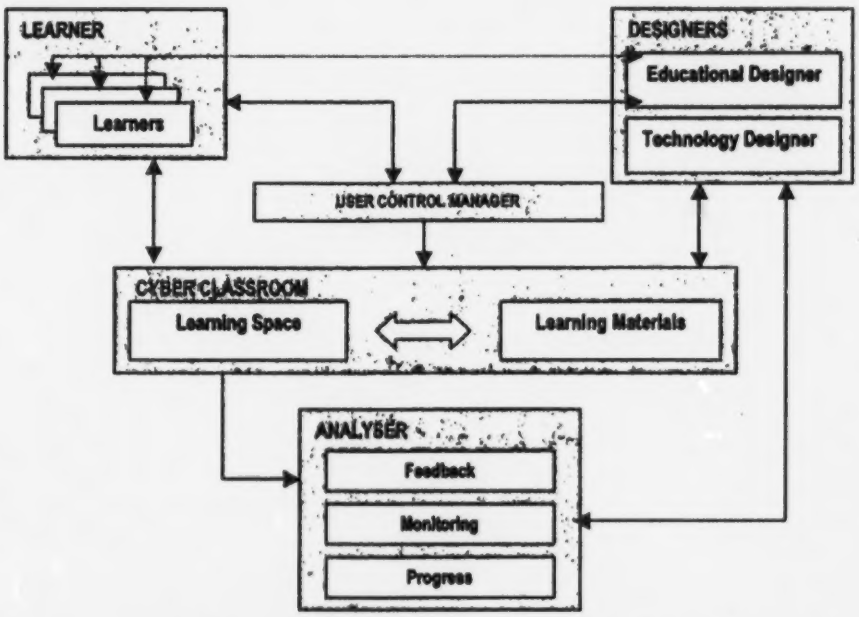
Monitoring learners' individual progress
Instructors are in control of monitoring the learners' individual progress. Based on the analysis of the learners' performance instructors can either guide or advise the learners through different strategies or modify the system.

Interaction and collaboration
The system must provide the capabilities to allow learners to interact with each other and with their instructors. This communication may occur, for example, through e-mail, and on-line forums. Physical, or face-to-face, communication is also a part of the model.

Assessment
Assessment is designed and administered by the instructor. This is to evaluate the students' learning performance and to provide feedback both to the educator and to the students.

4.2 Technology-mediated Adaptive Learning Model

The proposed model, the Technology-mediated Adaptive Learning (TAL) model, is composed of five modules: Learner module, Designers module, User Control Manager module, Cyber Classroom module and Analyser module, Figure 2.



Where ⟶ Technology-mediated communication (web browsing, down/uploading, email, forum, database updates, ...)
⟶ Physical communication

Figure 2. The Technology-mediated Adaptive Learning (TAL) Model

4.2.1 Learner Module

The learner module comprises the learner group. Learners interact with the TAL system through the Learning Space. Communication with instructors and other learners occurs within the Learning Space or physically, as indicated by the dotted line in Figure 2.

4.2.2 Designers Module

The designers' module can be composed of an educator, instructional designer, multimedia designer and technicians. This module is concerned with three main areas: the educational design, multimedia design, and computer and Internet technology. The educational designer is in charge of designing quality learning materials within a constructivist approach. This includes being aware of the subject matter as well as the pedagogical theory in use. The multimedia designer and the instructional designer help the educator to appropriately formulate the teaching materials for CBI or WBI. The technology designer provides the means to make the learning materials available to the learner group through a technology-mediated environment. Good skills and tools for multimedia authoring and technical services are required in this module, which may cause production cost issues.

4.2.3 User Control Manager Module

The User Control Manager allows the learner to customise the learning space. Through this module the learner can select the display mode to suit his/her own learning needs and preferences, for example, text, graphics, audio or video mode. Pacing and sequencing of the learning material can also be controlled from this module.

4.2.4 Cyber Classroom Module

The Cyber Classroom module is composed of two sub-modules: Learning Space and Learning Materials module. The Learning Space is where the learning is delivered. This is generally a kind of display unit, such as a personal computer or a network terminal screen. It may also include equipment for sound and video. It must be easy to interact with and be self-explanatory. Within the Learning Space the learner has the option of accessing learning materials provided by the educator, such as lecture notes, or external resources such as Internet sites or libraries

4.2.5 Analyser Module

The purpose of the analyser module is three-fold. First, it gathers statistics on the performance and progress of learners. Second, it records learners' perceptions about the learning material presented and about the overall working of the system (learner feedback). Finally, it monitors and records students' navigation patterns into a database. These will provide an indication of the learners' preferred learning styles. This information can be used to provide advice for the learner and to improve the system (Chavero *et al.*, 1998) by evaluating the existing materials and options and formulating new ones. The optimal implementation of the system will be to incorporate an Intelligence module to automatically generate and administer changes, based on the information within the database.

The TAL model is being implemented in a couple of different programming languages and database tools.

5 Reviewing learner control, constructivism and the TAL model

5.1 The TAL Model and Learner Control

The main objective of the model is to provide a technology-mediated learning system able to support learner control within a constructivist approach. The learner control variables, identified in Table 1, have been built into the model. Learning objectives, amount of information provided, monitoring of learners individual progress and assessment are overall controlled by the instructor, while the amount of information used/added/removed, material appearance and mode, pacing, timing, sequencing, place and location are potentially controlled by the learners. Interaction and collaboration can be initiated by either party as the need arises.

5.2 The TAL model and Constructivism

The underlying pedagogical theory governing the TAL model is based on constructivism, and specifically on the constructivist elements represented in the table below. The model addresses all elements, however, its concrete effectiveness will only be determined after development and implementation, in practice.

TAL Constructivist Approach Checklist	
EXPECTED CONSTRUCTIVIST ELEMENTS	**TAL MODEL**
• All learners are different	The model allows for learner differences in needs, learning styles, and skills.
• Learning is individual to each learner	Learners can customise the learning materials to suit their learning styles and needs through the User Control Module.
• A learner can learn at different speed levels in different situations	Learners can control pacing and sequencing of learning materials.
• A learner can engage in different learning strategies simultaneously	Learners can engage in linear and non-linear strategies. Also they can learn independently and/or seek collaboration.
• Learners learn best within a context.	Learning materials (provided by the TAL model) are always presented within a context.
• Learners construct and re-construct knowledge as they seek to understand and explain their environments	This feature is intended within the model but only after implementation will it be ascertained.

Table 2. TAL Constructivist Approach Checklist

6 Conclusion

This paper has addressed current educational trends on learner control within technology-mediated learning environments. The roles of the learner and the teacher have been reviewed and analysed in the light of technology-mediated environments.

The TAL model, based on constructivism, was presented, and its major functions were explained. The model includes five modules: Learner module, Designers module, User Control Manager module, Cyber Classroom module and the Analyser module. The aim of the model is to offer an adaptive learning system that caters for different types of learners and learning styles, with an especial emphasis on learner control. The model presented, empowers the learners and provides them with the means for constructing and re-constructing knowledge at their own pace within a constructivist framework that is learner centred and flexible.

From the designers point of view the model is a dynamic system that merges the capacity to deliver educational material with the ability to analyse learners performance (based on navigational patters and results) and system performance in order to either advise and guide the learner or to modify learning materials or their presentation.

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Learning algorithm design through interactive simulation

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The teaching of algorithm design is a subject of great difficulty, however, its value has not been addressed in the curriculum of computer studies in secondary schools. The aim of this paper is twofold: to describe the method and design principles of developing the Traffic Light System Simulator (TLSS) and to discuss a learning example of using TLSS. The TLSS is a learner-centred simulation tool for learning algorithm design. It provides a daily life problem in a learning environment. In solving the problem, students are encouraged to think and construct their own possible solutions. It is believed that the TLSS would inspire students to look beyond the traffic light simulation and transfer the insight to the learning of algorithmic thinking.

Keywords: **programming, algorithm, simulation, learner-centred**

1 Introduction

"Algorithmics is the spirit of computing" advocated by Harel [4]. Computer programming mainly consists of three activities - problems identification, analysis; algorithm design to tackle problems; and algorithm representation in a computer coded language [16]. Algorithm is usually defined as a method, procedure, recipe or step-by-step process for doing a job, or a finite sequence of unambiguous, executable steps that will ultimately terminate if followed, in which "unambiguous" means at each step the action to be performed next must be uniquely determined by the instruction and the data available at that time. Yet algorithm design is usually more challenging and problems-bounded as it involves solving continuous problems during execution [16]. To design an algorithm is to find a step-by-step procedure for locating a clue for errors [5]. This design activity entails an exceedingly diverse activity and involves complex cognitive processes. Difficulties in discovering algorithms are prevalent in the learning of computer programming.

The teaching of algorithm design is a subject of great difficulty, its value, however, has not been addressed in the curriculum of computer studies in secondary schools. Algorithm design has been revealed as an activity that demands abstraction, analysis, and synthesis abilities from students [3]. Therefore, the learning of algorithm design contributes not only to the teaching of computer programming, but also the cognitive development of students [17]. This paper attempts to address the importance of algorithm design in computer programming by examining the development of the Traffic Light System Simulator (TLSS), a learner-centred simulation program for learning algorithm design.

The TLSS, comprising simulation, animation, sound, text, graphics and video, aims to stimulate learners' interaction and initiative by simulating the actual algorithm design activities in learning process. As the word "interaction" indicates in its compounded use with multimedia. Interactive multimedia enables learners' communications, exchanges and involvement. Effective use of interactive multimedia enhances learning motivation and retention. Multimedia also provides an authentic environment which is relevant to daily life. The aim of this paper is twofold: to describe the method and design principles of the TLSS development and to discuss a learning example of using TLSS.

2 The Development of TLSS

In the development of the TLSS, the prototyping paradigm was adopted. Prototyping is a process allowing the developer to create a model of software that will be completed in the future. Like all approaches in software development, prototyping begins with requirements gathering [12]. However, Marques i Gralles [8] opines that the "development of an educational program always begins with an initial idea which seems to have the potential for enhancing particular teaching and learning processes". In other words, the development of TLSS, backed by Marques i Gralles' initial concept, has been supported by basic principles. The present model's principles are to apply the learner-centred approach as well as to nest with the understanding of teaching and learning algorithm design in secondary schools [18]. Grounded theory [3], which is a methodology for the systematic generation of conceptual models from qualitative data, was used to collect and analyse information from the interviews of teachers and students [20] during requirements analysis.

The label "grounded theory" means "the discovery of theory from data" [3]. Grounded theory is an approach of the handling of qualitative data and of the formulation of theoretical propositions in social sciences, and this methodology has been used successfully for conceptual analysis in a number of information system development projects [11].

Strauss [15] presents a "concept-indicator model" to direct the conceptual coding of a set of empirical indicators. It is a possible operation of concept formation from qualitative data. Indicators are labels for actual data, such as behavioral actions and events, observed or described in documents and in the words of interviewees or informants. By constant comparison of indicators to indicators and their related data or documents, the researcher is forced into confronting differences, and degrees of consistency of meaning among indicators. This generates an underlying uniformity, which in turn results in coded categories, coded relations, definitions and properties of categories and relations, and theoretical concepts.

In order to develop a system "grounded" from the teaching and learning of teachers and students, twelve teachers and ten students from various schools were interviewed. The following issues were addressed in the interviews: (1) to identify the difficulties of teaching and learning of algorithm design in secondary schools, (2) to examine the needs, skills, and interests of students in the learning of algorithm design, and (3) to identify a series of problems conducive for learners' further exploration and motivation. Data were analysed using the constant comparative method in grounded theory.

The following is a brief summary of some major findings supporting the TLSS development: (1) algorithm design is too abstract to some students, (2) students are lack of logical thinking skills, (3) some teachers think that learning algorithm design is very important, (4) some teachers think that algorithm design can be learned naturally, (5) students' existing mental model is an important factor of learning algorithm design, (6) most students cannot decompose problem into sub-problems, (7) there is a lack of teaching material in algorithm design, and (8) the curriculum is not related to daily life.

The results also reveal that teachers use either teacher-dominated method or subject-centred method. Teachers with teacher-dominated method "are serving the immediate needs of the dependent, authority centred, linear thinking students" [9]. Teachers in this case direct students' learning through a straightforward lecture of textbook and presentation. Teachers who teach with subject-centred method "are providing more information and use a greater variety of presentation method" [9]. The responsibility for learning is on students, while the teacher primarily provides opportunities for learning to take place. Most teachers adopt this subject-centred method. They teach with metaphors, examples, pictures or games. Apart from textbooks, they also prepare notes, laboratory sheets, and supplementary exercises as teaching materials.

The discovery method of instruction for teaching computer programming is one of the major focuses in educational computing research [14], and discovery learning occurs when a learner is motivated to act and allowed to formulate and test questions or answers [7]. A number of studies suggest to connect computer programming with logic, truth tables, switching circuits, gating symbols, flow charts, pseudocode and visual simulation enhance the teaching and learning of computer programming in secondary schools [1]. Other studies indicate that algorithm animation seems to be a useful tool for teaching algorithm [6].

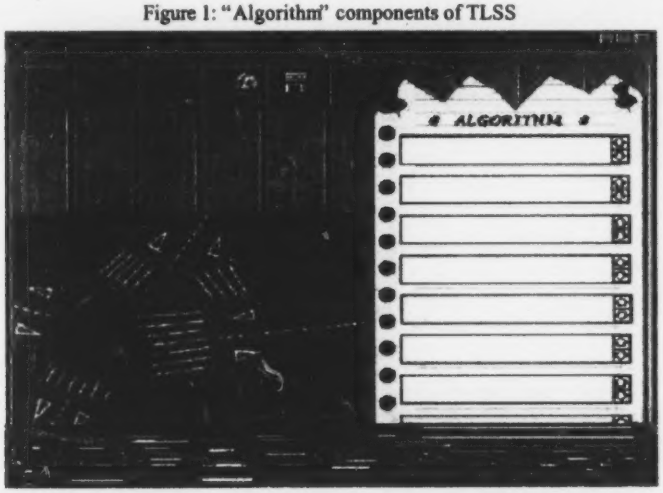
Further to these observations, this paper focuses on the learner-centred approach which facilitates active, multi-functional, inspirational, and situated educational experiences. The basic principles of learner-centred

approach can be summarised as: (1) problem-driven rather than structured analysis of the curriculum content; (2) attending to learners' needs, skills and interests; and (3) learning on a constructivist approach.

3 The TLSS Simulation

The TLSS embraces two distinct features. First, the system provides students with an authentic multimedia context that will motivate students to learn and explore [19]. The system allows continuous feedback and challenge to stimulate students to decompose the challenge, thus keeping students continue learning activities [13]. Second, students might benefit from actively constructing the algorithm than passively watching the algorithm. The system supplies a visualised simulation and an animated environment which students are actively immerse in creating, exploring, testing, and understanding their implemented algorithms.

Figure 1: "Algorithm" components of TLSS



The TLSS provides a dynamic model of a traffic light system with simulated roads, traffic lights, vehicles, pedestrians and various traffic situations. It allows students to present and test their algorithm of controlling a traffic light system in animation. The system also represents students' algorithm in Pascal programming language to reinforce programming language learning.

The TLSS consists of two major components namely, "algorithm" and "simulation". In the "algorithm" component, users are asked to design an algorithm using "while", "for" and "if-then" to control five sets of traffic lights at a junction (Figure 1). Students are expected to begin by simple guided situations on resolving two traffic lights. Each "if-then" will be contained in statement 1 and 2 of a set of algorithm design. Implanting "if-then" statements may be relatively simple and direct for most students. Other components, "for" and "while", targeted at coupling the algorithm with variables and validity, complicates the activity. From the outset of the compilation, students will be given no explanation of the set, "if-then", "for/while", but be guided on a step-by-step traffic light simulated situations to generate in them understanding of the syntax. Students will use each set of algorithm, represented as statements ensuring the smooth running of traffic lights, to assign the colour of traffic lights and its time span. Incorrect input of algorithm or a change of the idea can be rectified by pushing the "undo" button. The "save" button enables students to retain their exercises. After compiling the algorithm, students can proceed to the "simulation" component by pushing the simulated button for execution of their design. Evolved will be an animated environment. Since the aim of the designed algorithm is to ensure the safety of pedestrians and vehicles, correctly compiled algorithm yields smooth running of traffic while incorrect algorithm gives rise to accidents. Accidents are categorised into car crash and car bumping into pedestrians. Figure 2 is a graphical presentation of a car accident in the simulation.

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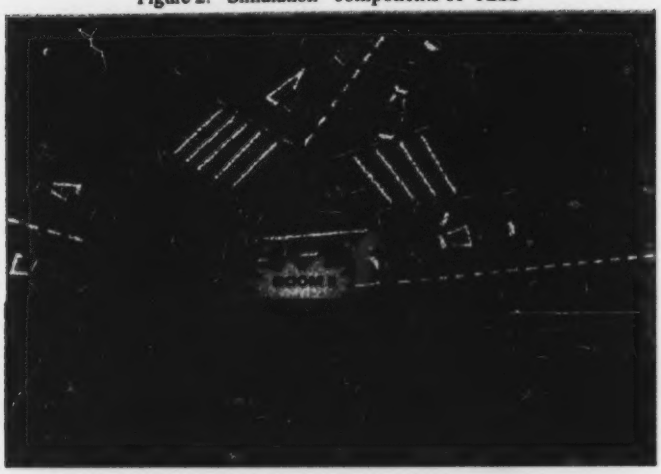
Figure 2: "Simulation" components of TLSS



If an accident occurs, users may return to the "algorithm" component to re-compile another possible algorithm and test it again. The activity allows students unlimited trials of designs and implementation. Because solutions to every situations are totally dependent on the success of the algorithm design, students' problems solving, engagement in critical thinking to reach for the success stage are crusts of the TLSS.

4 Shirley: A Learning Example

A preliminary version of the TLSS has been developed, and a group of secondary 5 students (Grade 11) with average academic ability were asked to use the TLSS for learning algorithm design and computer programming. The process of using the TLSS was observed. Because of the volume of data generated, the case of only one student, Shirley, was reported and discussed in this paper.

A sequential activity comprising a series of exercises to guide students to the final operation of all five lights is assigned (see Appendix). Each student, engrossing in the learner-centred approach, will freely discover problems and solutions on their own. Also, as featured in the approach, questions will dominate the exercise so that students can actively engross in the revelation of questions. Students are encouraged to try out patterns so as to simulate the "debugging" process of programming environment. Emphasis of the exercise will not only be the success of compilation, but on the process of compilation. The process of compiling a simulated TLSS demonstrates ways of how students can plan, debug and execute a computer programme.

Shirley, who has completed one-year programming learning practice in her secondary 4 (Grade 10) studies, started the activity by following the assignment instruction. She operated the TLSS and set the simulation off by pushing the button at the very first instance. By observing the simulated junction, Shirley tried to locate directions for the movement of cars and the operating sequence of traffic lights but of no avail. Shirley found that all traffic lights, cars and pedestrians were not working and in stand-by mode. Simulation could not be executed because algorithm was not compiled.

Having finished observation, Shirley returned to the menu and tried to familiarise herself with the available syntax of the simulation. She tried put the "If..Then" onto one of the boxes and observed the pattern of its appearance. The representation of "If..Then" as conditions to be fulfilled was acknowledged. Double-clicking the "statement 1" box, Shirley realised it was the first condition for the first part of the algorithm and the "statement 2" box was ignored. Returning to the assignment instruction, Shirley began to work on how she could survive for 20 seconds if lights 1 and 2 were simultaneously working. Without a second thought, Shirley inserted "red" and "20 seconds" for light 1 and the same for light 2. Two "If..Then" statements appeared after hitting the "OK" button. A simulated environment was followed where all pedestrians crossed the road at ease. Some pedestrians were standing on the traffic island. Shirley considered that it was due to some pedestrians were heading to light 3 area so they kept waiting on the island. The assignment question on the difference of the situation between the reality and the simulated

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environment also reinforced Shirley's belief that some pedestrians were on different directions. Shirley failed to recognise the time of traffic light was determinant in affecting pedestrians' continuation of crossing the road. That misunderstanding gave rise to recurrent traffic accidents in other activities which required much longer time.

Having triumphed on the first part of the exercise, Shirley tried to make a car crash as required. For convenience, Shirley followed instructions strictly. She produced "light 2" as "red" for "20 seconds" and "light 5", "red", "20 seconds". A first car crash was experienced. It was too quick a crash and Shirley missed out the sequence, details and picture. Shirley could not answer the first question of how long it took for the first collision. Shirley decided to study and read carefully questions provided by instructions before finding out solutions. By returning again two times to the simulation, Shirley concluded that the crash took place after 8 seconds of execution. In order to remove the accident, Shirley had to find out a workable algorithm. Shirley tried to visualise the traffic pattern in her mind but was not successful. She then realised it was because the most important element of vehicles direction was not recorded. Pens and paper were ready before Shirley returned to the simulation again. She then looked for patterns of the traffic and pictured it onto the paper. She devised that light 2 should stay red long enough to allow light 5 cars to run. Although unsure about the result, she kept light 5 as red for 20 seconds and light 2, red, 40 seconds. The result was successful and Shirley proceeded to the third part of the exercise.

The third activity requested Shirley to run the car more than once. Suggestions on using "For" button was put forward. On devising "for i = 1 to n", Shirley did not understand the function of "n". No hints were given. She did not know where to put the "for" trunk at the infant stage. After several unsuccessful hits of trying to make the equation (e.g. "i" equals "10" and "n" equals "9"), Shirley took an hour break. Shirley returned and read carefully the instruction again. She decided to insert "for i = 1 to 5" and retained the previous lights 2 and 5. A first success was experienced. She concluded that "if" functioned as an executable command while "for" predicted the number of execution of the "if" command.

The fourth activity demanded Shirley to keep cars running forever. Shirley did not understand what was meant by the "for-loop" inside the "while-loop" as delineated in the activity. She tried to put the "If..Then" statements first, and then the "while-loop", the "for-loop". Consecutive errors led Shirley back to study questions carefully again. She devised the sequence of the "for-loop", the "while-loop" and the "If..Then" statements. Working out the sequence, Shirley realised that the "while" statement should always remain "True" because it kept the "If..Then" to continue for "n" times. The "If" just started the programme and "while" was a continuation command.

The fifth activity asked why car accidents occurred. The activity required Light 3 as red for 10 seconds while light 4, green 14 seconds. An alternative could be light 5 as green for 16 seconds. Shirley selected the first combination (light 3 as red for 10 seconds and light 4 as green 15 seconds) but a car accident occurred. After trying out a couple of combinations, Shirley shifted to the diagram she drew before. She worked out the flow of cars, wrote down seconds next to each light. She went back to four previous activities to devise solutions. She attended to her negligence of the importance of time element in activity 1. She finally could not contribute colours and time to lights as she could not work out the transition time of lights passing through red to green. Shirley believed there should be intermission for red-yellow and yellow lights. She recorded every combination and observed its execution. Shirley then tried to perform a monitor system by checking the time for accidents taking place like the guidance referred by activity 2. After almost 20 combinations, Shirley referred back to the question and decided to remove the "for-loop" and the "while-loop". No traffic accident occurred because there was no repetition of car flow. Shirley, however, was not satisfied with the result because reality traffic required continuous flow of cars. She tried to learn from experience in activity 2 that one light's stopping time should be longer than the other's flowing time. After almost 30 trial and errors, Shirley reached the conclusion that emphasis should be on the transition lights. Finally, Shirley gave up algorithms without reaching successful traits. The last activity requested the smooth running of cars by operating all traffic lights. Shirley did not proceed to this stage and the assignment was handed in.

5 Discussion

In the observation, we found that students using the TLSS were encouraged to participate in the thinking process of designing algorithm, such as imaging a goal, formulating a goal, inventing a product, finding alternatives, choosing the solution, generating more alternatives, making choice and evaluating choice,

which are essential elements in algorithm design [5]. In contrast with the teacher-dominated and subject-centred method, the learner-centred approach is based on the idea that "people learn best when engrossed in the topic, motivated to seek out new knowledge and skills because they need them in order to solve the problem at hand" [10]. In learning with the TLSS, students are involved in active exploration, problems solving and construction rather than passive teacher-directed lecturing. Such learner-centred simulation tool also generates in learners a long-term pursuit of examining the subject which leads to lifelong learning. Further exploration enhances creativity and critical thinking. However, some students, in particular the case of Shirley, revealed that teacher's guidance is also crucial to make such active learning successful.

The design of the TLSS is based on the learner-centred principles as well as grounded from the experiences of teachers and students. The primary goal of the TLSS is to provide a daily life problem in a simulation environment. In solving the problem, students are encouraged to think and construct their own possible solutions. Simulation, by definition, is not real. Most simulations are artificial systems that can in no way come close to the real situation in complexity and variety. In TLSS, the operation of the traffic lights is certainly different from real life. Thus, students must always be alert for the limitation of simulation. It is believed that the TLSS would inspire students to look beyond the traffic light simulation and transfer the insight to the learning of algorithmic thinking.

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Appendix: Sample Activities

How can you survive for 20 second?

- **Objective:** By the end of the activity, students should be able to use "IF ..Then" statement by using trail and error approach. Use basic problem solving skills. The activity allows the students to explore the implementation of the "If..Then" statement.
- **Activity:** In this simulation, students only use "IF-THEN" statement to control the traffic flow. (Hint: Ignoring Lights 3 to 5 and congests for route 3 to 5, control Light 1 and 2 only. Observe the pedestrians' flow).
- **Questions for Discussion:** Why there are some pedestrians standing on the traffic island? Is there any difference between the reality and the simulation?

How can we make the car running more than once?

- **Objective:** By the end of the activity, students should be able to get more familiar with the characteristics and function of the "for" button.
- **Activity:** Students should first use "for i= 1 to n", where n is any chosen number. We should predict what would happen before we run the game. No instruction will be given to students so students can make the simulation by their own. For instance, how many times of car flow occur if we set for i = 1 to 5 and put in one condition such as controlling light 1 & 2 as we tried before, inside the loop?
- **Questions for Discussion:** What is the function of the "if" statement in programming? What is the benefit of using this button?

How can we make the car running continuously?

- **Objective:** By the end of the activity, students should be able to get more familiar with the characteristics and function of the "while" button.
- **Activity:** Students are asked to control the car flow so that the car flow can run continuously. We can use the "while" statement to implement this task. "While" it is true, then do the following statement. Students are suggested to predict the effect of putting the "for-loop" inside the "while-loop" and the vice versa. They are asked to explain these effects.
- **Questions for Discussion:** What is the function of the "while" statement in programming? What are the differences between "if" and "while"?

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Learning with Computer Mediated Communication in Remote Off-campus Cross-Cultural Contexts: Bridging the Information Gap

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The research examined the anxieties and perspectives of first and final year Australian Indigenous Bachelor of Education students as they learnt with Computer Mediated Communication. The paper reports a qualitative study that utilised Likert Scale Questionnaires and focus and individual interviews in order to ascertain the factors involved in reducing the information rich/information poor gap through the use of Computer Mediated Communication. The factors identified involved technical, time, skills, costs, tutors, and "learning style" issues as well as isolation as tertiary students studying in offcampus remote communities. The students reported more positive attitudes and competency skills and less isolation with email than the WWW. There was general optimism concerning the role the Internet would play in their future lives as students, teachers, and, as they took their knowledge beyond the classroom, in their communities, particularly in terms of reducing the information gap.

Keywords: **Computer Mediated Communication, information gap, cross-cultural, Internet**

1 Introduction

Tertiary education institutions are rapidly investing considerable resources and faith in the Internet as a means of conveying both the administrative and the pedagogical materials for student learning [1, 2]. As vehicles for flexible learning, email and the World Wide Web (WWW) are seen to be free from geographical, time, and participation restraints [3, 4]. This is juxtaposed against international concerns that the Internet is widening the gap between the information rich and information poor [5, 6]. Tertiary institutions are amongst those that continue to widen the gap between information rich and information poor in Australia as technical, cost, and inappropriately designed distributed learning environments (email and the WWW) impose implementation restraints. This paper reports a case study of how Australian Indigenous students, who are studying in remote communities, and one Australian tertiary institution, James Cook University, are bridging that information gap.

The study was interested in the tertiary students' perspectives of the influences that impacted their interpretation of that gap and how it was being bridged. We therefore investigated the students' perceptions of (a) their attitudes and anxieties concerning email and the WWW and (b) the role email and the WWW played in teaching and learning in their degree program and their lives as Indigenous peoples in remote areas.

2 Methodology

Since mid-1990, James Cook University (JCU) has offered a Bachelor of Education to Aboriginal and Torres Strait Islander students through the Remote Area Teacher Education Program (RATEP). As in the rest of Australia, Queensland's Aborigines and Torres Strait Islanders have lived, and many continue to live, under various separatist legislation. The state government long held an isolationist and racist view of what constituted an appropriate education for them. As the official view was that they could achieve little academically, secondary education was withheld from Aborigines until 1964 and, for Torres Strait Islanders, education was left in the hands of the Department of Native Affairs, rather than the Department of Education, until 1984. RATEP was conceived as a program that would seek to redress issues of geographical remoteness, racial discrimination, economic exploitation, educational marginalisation, linguistic plurality, land alienation, and enforced dependency of the Indigenous communities. It was driven by the concepts of social justice, culturally contextualised education, empowerment, and use of information technologies. It is an inter-systemic teacher education program providing preservice teacher education studies to Indigenous students on-site in remote locations throughout the State of Queensland. The RATEP delivery partnership consists of James Cook University, the Far North Queensland Institute of Technical and Further Education, the Queensland State Education Department, and, importantly, the Indigenous communities. Multi-systemic collaboration is effected through the RATEP Management Committee which oversees finance and site selection, contributes to various corporate decisions, and provides for direct Indigenous input.

The program caters for eight to 35 Indigenous students in any year's intake with four to 12 students at any one site. The location of the 10 James Cook University RATEP centres is usually in a primary or secondary school classroom in locations where the population ranges from 250 in Aboriginal and Torres Strait Islander communities, in which non-Indigenous people are a very small minority, to 700 in the small townships. Typically, the centre consists of one classroom which houses the computers, modem, printer, facsimile machine, teleconference phone, conference table, and study desks as well as a sink and fridge. There are no community libraries available to the students.

RATEP is a mirror of the Bachelor of Education on-campus program, differing mainly in modes of delivery. RATEP students study the same courses, are taught by the same lecturers, complete assessment tasks at the same standard as their on-campus counterparts, and receive exactly the same award as students who undertake preservice teacher education at the Cairns and Townsville JCU campuses. RATEP uses various distance education technologies, materials, and delivery strategies: textbooks, workbooks, teleconferences, audio and video tapes, facsimile, JCU developed interactive multimedia (IMM) courseware, on-site tutors (self-labelled teacher-coordinators), and, now, the Internet.

The delay in accessing the Internet as part of their program was mainly due to the costs of hardware, long distance telecommunication fees, and the unreliability of sustained telecommunication connections. With support through a Telstra learn-IT research grant, the Bachelor of Education students through RATEP were able to enrol in two undergraduate information technology courses that utilised the Internet as a teaching-learning tool. The courses were a first year core on-campus course and a fourth year elective: *Information Technologies in Education* and *Design of Educational Media*, respectively. The first year course had the equivalent of two interactive lectures on the World Wide Web (WWW). Assessment included reactions to tutorial readings sent as email attachments, and the option to create a WWW home page. Interaction with the lecturer was via email and teleconference. The fourth year course required the students to access the WWW for key readings as well as to critique educational sites. In addition, they were responsible for conducting weekly email tutorials in which two students posed email questions about the set tutorial readings. All students replied individually. The tutorial leaders were also required to synthesise these responses in a culminating email. All students were encouraged to critique any of the contributions. Except for two teleconferences, interaction with the lecturer was via email. In both subjects, the students had previously met formally and informally with their lecturers during a short orientation oncampus program.

Twenty-three out of 33 Indigenous students volunteered to participate. Their ages ranged from 21 to 49 years. Reflecting teacher education enrolments generally, all but seven were female. The students generally speak either a traditional language, Aboriginal English, or Torres Strait Creole as their first language. Standard Australian English is their second or third language. When researching in cross-cultural contexts it is important that researchers acknowledge the cultural, linguistic, and individual differences existing within and across the student group. However, the historical-socio-cultural similarities are strong enough to speak in generalities in referring to Aboriginal and Torres Strait Islander patterns of experiences, values, and ways of

learning.

Audiotaped focus interviews were conducted either face-to-face (Yarrabah) or via teleconference (Normanton and Woorabinda) with students as a group at these three RATEP sites. The interviews involved open-ended questions to gather information about the issues identified by the students and teacher coordinators as relevant to learning with the Internet. A five-point Likert Scale Issues and Course Questionnaire for the first and final year courses were compiled from the focus interview data and the literature. It was administered towards the end of the courses, either along with audiotaped individual interviews conducted on site with students at six RATEP sites (Thursday Island, Bamaga, Napranum, Cairns, Palm Island, and Cunnamulla) or via fax or email attachment to the other four sites (Yarrabah, Normanton, Worrabinda, and Doomadgee). Another five-point Likert Scale questionnaire assessing Computer Mediated Communication Anxiety [7] was also administered at the beginning and end of the two university courses involving the Internet via fax or email.

3 Data Results and Discussion

The five point Likert scale questionnaires were reduced to a three point scale (see Table 1) for data analysis. Overall there was a positive swing on the Computer Mediated Communication Questionnaire (Items 1-13, Table 1) and the Issues and Course Questionnaire (Items 14-23, Table 1) that sought first and final year student anxieties and perceptions about current and future usage of email and the World Wide Web (WWW). (Ten items out of the 42 item Issues and Course Questionnaire are reported here; the other items included those that are common in end-of-course evaluations and, therefore, not relevant to this paper). The individual interviews supported this trend. The interviews revealed a decidedly positive emphasis on keeping but improving the use of CMC in RATEP subjects.

Table 1: Comparison of Pre to Post Test Changes on Selected Items from Computer Mediated Communications and Comparison between End-of-Semester First Year and Final Year Issues and Course Evaluation Questionnaires

Computer Mediated Communications Questionnaire: Responses of Students' Studying First and Final Year Course							
Item		Pre-Test			Post-Test		
		SA-A	U	D-SD	SA-A	U	D-SD
1	E-mail could open up new communication channels for me.	92%	8%		94%	4%	
2	My usage of e-mail will increase in the future.	67%	33%		91%	9%	
3	The thought of using e-mail makes me nervous.	50%		50%	30%	9%	61%
4	The Internet could open up new areas of communication for me	100%			100%		
5	I expect I will use the Internet in the future	83%	8%	8%	96%	4%	
6	I get nervous at the thought of using the Internet	50%		50%	39%	13%	48%
7	I believe that there are many useful ways to use the Internet.	67%	17%	17%	68%	17%	14%
8	The thought of learning from the Internet intimidates me.	36%	27%	36%	30%	17%	52%
9	Information overload frightens me.	50%	8%	42%	43%	30%	26%
10	I feel very negative about the Internet in general.	33%	17%	50%	26%	30%	43%
11	I would prefer not to use the Internet because of the uncensored material	25%	8%	67%	30%	22%	48%
12	Using the Internet could be more trouble than its worth	25%	33%	42%	17%	17%	65%
13	I think there is too much emphasis placed on	67%	17%	17%	35%	26%	39%

	the Internet						

First and Final Year Issues and Course Evaluation Questionnaire Responses

	Item	First Year Course			Final Year Course		
		SA-A	U	D-SD	SA-A	U	D-SD
14	I am more confident using email than the WWW	73%	9%	18%	67%	11%	22%
15	If I had the choice, I would use the WWW for serious information searches	100%			100%		
16	If I had the choice, I would use the WWW to catch up on what' s happening in soap operas.	27%	9%	63%	33%	22%	44%
17	The WWW is a diversion from having to do RATEP work.	20%	20%	60%	22%	33%	44%
18	I don' t feel as isolated as a university student now that I can use WWW	54%	36%	9%	56%		44%
19	I don' t feel as isolated as a university student now that I can use e-mail	82%		18%	100%		
20	I appreciated the flexibility in scheduling my learning times	73%	18%	9%	89%	11%	
21	The subject has made me feel a more independent learner	50%	30%	20%	78%	22%	
22	I no longer see the computer as just a word processing tool	100%			80%	20%	
23	I intend using the computer in the classroom with my students.	100%			100%		

* SA-A = Strongly Agree/Agree; U - Undecided; D-SD = Disagree/Strongly Disagree.

Students were originally divided on their willingness and nervousness to use email. By the end of the semester there was a substantial increase in their perception that their future usage of email would increase (67% to 91%) and a 20% decrease in their nervousness (Items 2 & 3, Table 1). This is encapsulated in one student' s interview statement: "I was a bit apprehensive at first because I think the newness with everybody was a bit scary. But, after I got the knack of things, I really loved it" (Interview). Most students acknowledged the efficiency and speed of communicating via email with their lecturers and fellow students; as one student explained: "...you don't have to fiddle around faxing or posting your assignments. You just type it right onto the computer and send it on the email and it's there!" (Interview). Some reasons for the maintenance of apprehension involved concerns about costs ("the time I' m using is costing money"), typing skills ("my typing speed is not up to my thoughts; that' s a bit slower so that' s what holds me back"), and privacy ("...the teacher-coordinator seemed as if to be spying" (Interviews). This last factor involved the way email accounts were established. Because of costs, only one modem was provided at each site. Thus, at the time of the research, the teacher coordinator accessed and therefore could read all exchanges as the single email account for each RATEP site was registered in their name. (This year, all students have a private email account.) Despite their concerns and apprehensions, 94% agreed that email would open up new communication channels for them while 91% indicated they would increase their use of email in the future (Items 1 & 2 respectively, Table 1).

Compared with email items, there was more initial negativity and some smaller positive swings concerning the WWW items. Indeed, at the end of the semester, both first and final year students admitted they were "more confident using email than the WWW" (73% and 67%, respectively; Item 14, Table 1). In the pre and post Computer Mediated Communication Questionnaire, for instance, although in the post test 68% agreed with the item, "I believe that there are many useful ways to use the Internet", there was little variation from the pre test (67%) (Item 7, Table 1). Other small positive results occurred in the following items as fewer students indicated agreement with the following statements: "I get nervous with the thought of using the Internet (50% pre test to 48% post test); "The thought of learning with the Internet intimidates me" (36% to 30%); and "Information overload frightens me" (50% to 43%) (Table 1, Items 6, 8, & 9, respectively).

However, it is noteworthy that on three of these items such positive swings were offset by a noticeable

increase in the "undecided" category. For instance, in the above item about nervousness and using the Internet, 50% agreed and 50% disagreed on the pre-test while 39% agreed and 48% disagreed on the post-test (Item 6, Table 1). The change in attitude was counteracted by an increase in the "undecided" (0% to 13%; Item 6, Table I). Although more students felt less negativity about information overload (Item 9) and the WWW in general (Item 10), 30% reported being "undecided" in the post test compared with 8% and 17% in the pre test, respectively (Items 9 & 10, Table 1). As explained later, many of the first year students were prevented from hands-on use of the WWW course materials online. In the fourth year subject, the greater emphasis was on email tutorial interaction; in comparison, finding relevant resources and obtaining set readings from the WWW were the only compulsory WWW tasks. This paucity of "compulsory" usage, influenced the students perceptions concerning the Internet. During the interviews, most students equated the Internet with the WWW. The experiences that the students did have seemed to have resulted in understandable ambiguity concerning their anxiety and general attitudes about the WWW; the reality of their experiences was a contributing factor.

More substantial changes occurred when, in the post test, fewer students agreed with the statement, "I think there is too much emphasis placed on the Internet" (67% to 35%) (Item 13, Table 1) and more students confirmed that they would use the Internet in the future (83% to 96%) (Item 5, Table 1). As one student commented: "You have to keep up with the technology and pass it on; it's never-ending learning" (Interview). Additionally, regardless of their concerns and experiences, an optimism remained: all confirmed an unchanged hope that the Internet would open up new areas of communication for them (100% on both pre and post tests, Item 4, Table 1).

There were several factors affecting these data results, such as technical issues, time, skills, costs, and tutors (self-labelled "teacher-coordinators").

Technical problems were a significant factor. Getting hooked-up took two sites one month after the commencement of the courses. The reliability of the telecommunication links and difficulty in logging into the James Cook University site when 500 on-campus students were trying to log into the same first year course site influenced the RATEP students' perceptions (Interviews). The one computer that had the RATEP modem connection was also used for studying with the IMM courseware and wordprocessing assignments. An extra major inconvenience for two sites was having just one line for Internet access, facsimile, telephone, and teleconferencing. There was a ratio of approximately four students to this one line.

These factors obviously limited the time each student could spend using the WWW and email. Their other study commitments - described as "a mountain of work" by one student - imposed further time constraints reducing their usage of the Internet (Interviews). This was exacerbated by having English-as-a-second/third-language with respect to deconstructing academic genres. "If we'd had more time to explore it and build up that confidence, well, then, I probably wouldn't be feeling as bad as I do about getting onto it," was one student's summary of the effects that lack of time had on her self-confidence (Interview). Others echoed the impact that minimum usage had on their confidence to use the WWW (Interviews). The printout of procedures on the wall did not seem to inspire usage or confidence; it was the personal input from the teacher-coordinator or a peer that some students' maintained was crucial. This emphasis on the personal coach would seem to reflect Aboriginal and Torres Strait Islander preferred ways of learning and doing [8]. In this period of apprehension with using the Internet, students required the comfort zone of traditional ways of teaching and learning [9].

Underdeveloped procedural knowledge constrained student progress using the WWW. One student's clarification echoed other students' comments: "...it's just a matter of not being able to get where I want to be straight away ...and then I'll get real frustrated" (Interview). Students justifiably argued that this was compounded by the fact that the first year course did not encourage understanding or reinforcement of WWW searching strategies by requiring assessable activities in this area.

There was evidence of self-imposed moderation in usage by students (Interviews). In spite of their understanding that costs involved in browsing the WWW were met through the Telstra learn-IT grant, students were reluctant to abuse what they saw as a privilege.

The students who reported most positively in their interviews were those who perceived their teacher-coordinators as having competence in using the WWW and being able and willing to impart that confidence

to the students. Unfortunately a few students cited perceptions of teacher-coordinator reluctance or inability to share their knowledge. Also most of the teacher-coordinators printed out the first year course's WWW lecture notes. The teacher-coordinators contended they chose this strategy because of time constraints, technical hiccups, and, perhaps, admitted one, procedural insecurities. For them, this allowed a more efficient usage of time as they could conduct tutorials based on the printed text without having to wait for all the students to study from the WWW. In effect, it prevented students acquiring more proficiency with the Internet and, hence, much needed self-confidence. As well it prevented students (and these teacher coordinators) from obtaining a better understanding of how the WWW could be utilized as a learning tool as they had no chance to participate with the in-built question-answer-feedback interactions, the video clips of school children voicing their perceptions of various aspects of the Internet and its relevance to their lives, and the hypertext/hypermedia functions of the WWW.

These conditions would have influenced the differing perceptions about the courses allowing "me to feel a more independent learner" (Item 21, Table 1): only 50% of the first year students felt such independence with a further 30% being undecided; in comparison, 78% of the final year students reported that the Internet activities had helped them to take more self-responsibility for their learning. Of course, one would expect that final year students would be more independent learners than first year students. Nevertheless, the item required them to express an opinion if the Internet subject had made them "more" independent.

Even if many had not had much opportunity to browse the Web, all students reiterated the commonly quoted advantages of the WWW: up-to-date information, variety of topics, exploration, multiple sources relating to the same information, and flexibility (Interviews). With respect to flexibility, more final year students (89%) compared with first year students (73%) valued this attribute (Item 20, Table 1). The enforced tutorials without personal access to the WWW would have influenced the first year students' perceptions. One student situated her comment in the context of the realities of Indigenous community life: "We've had multiple tragedies in our class [deaths, suicides, and serious illnesses]; at least with the WWW lecture notes, we can come back and get them; we're not missing out [as we would have with teleconferences]" (Interview). For students who had taken opportunities to surf, the WWW was "Exciting!"; "It gets me; it draws me. I could see myself seriously getting hooked"; "It's like a big book; you don't want to put it down!" (Interviews).

Students unanimously agreed that they would use the WWW for serious information searches (Item 15, Table 1). It was reassuring to see that their usage went beyond the two courses requiring utilisation of the Internet. The following Web searches were mentioned by different individual students: green ants (for their science curriculum course); background information on a son's medical disease; solutions for our farm's fruit tree problems; Indigenous sites such as the internationally famous Aboriginal band, Yothu Yindi. Serious play [10, 11] was involved, too: finding out what was on at movie theatres; joining a jokes' listserv; 30% admitted to catching up on soap operas (averaged first and final year, Item 16 Table 1); and 21% reported using the WWW as an occasional diversion from their studies (averaged first and final year, Item 17 Table 1). Such responses demonstrate these students' awareness of the types of information available on the WWW and an ability to conduct searches and find out how to subscribe to a listserv. Because of the Internet and other computer requirements in the two courses, 90% (averaged first and final year students, Item 22, Table 1) agreed that they no longer perceived the computer as just a word processing tool.

The role of email and the WWW in their lives as students in remote Indigenous communities involved reducing isolation and person, societal and professional issues.

Feeling part of the wider JCU student cohort was an issue raised in the research. Both cohorts of students felt that isolation as a university student was decreased through use of email - 82% for first year students and 100% for final year students (Item 19, Table 1). One student put it succinctly: "Yeah. It took away the isolation a lot" (Interview). In comparison, approximately half (54%) of the students studying the first year course reported that they "did not feel as isolated as a university student now that I can use the WWW" (Item 18, Table 1). A further 36% were undecided. Likewise, only 56% of the final year students felt that isolation as a university student was reduced through access to the WWW (Item 18, Table 1). The course requirements and amount of access would have been significant issues in the differing percentages with respect to email and WWW as factors in lessening isolation. With respect to the first year students, these percentages are not surprising considering the large number of reports of inadequate access to the WWW, working from a print version rather than on-screen interaction of the first year information technology course, and technical constraints. The fourth year course demanded that the students conduct weekly email tutorials

and interact via email for a fortnight with students at the Royal Melbourne Institute of Technology as well as the fact that their compulsory WWW activities were limited. The results may also have been affected by the fact that the WWW activities were not people orientated whereas the email tasks were obviously so.

However, isolation was not just a matter of the difficulties imposed by distance learning with respect to cultural induction as university students. It was also a personal and community issue. A few students reported keeping in touch via email with relatives and friends living in other parts of Australia; for instance, one student was able to regularly contact her son who was in jail. This is a poignant reminder of the systemic injustices involved in Aboriginal and Torres Strait Islander peoples' reality and the role that email can play in helping families maintain contact at a geographical distance. The WWW was threatening for one student: " ... a whole new world, and I'm afraid in a way to experience all these different things" (Interview). For others, their world was expanded. This was insightfully expressed by one student: "When you're living in a remote community all you know is what's happening around here or what you get from your teleconference and stuff like that. You're living in your own world ...Well, then, when you get onto the Web, it's just like: 'Wow! There's a big world out there. All that information you can access'." (Interview).

The content in the first year course *(Information Technologies in Education)* appeared to have been influential in changing perceptions about the negative affects of the Internet. One involved society's concern that the Internet would significantly reduce or even prevent socialisation. For example, "I've changed", said one student. "I've done a complete [voice faded out] ...with the whole idea of technology taking away the emotional side of life and that we've been becoming too dependent on it, and I think, after going through the semester with it, that maybe as long as people are educated in the right way about it, it's not going to prove to be a big problem. It's probably going to prove to be a big asset, you know." Some students' comments highlighted their fear of children and themselves encountering pornographic sites: "It scares me - to come across something like that on the Internet"; "Children shouldn't have access to them" (Interviews). However, the 19% pre to post drop in their disagreement with the statement, "I would prefer not to use the Internet because of the uncensored material" (Item 11, Table 1), probably reflects a more realistic understanding of avoidance strategies and the general unlikelihood of a user encountering such sites; these were issues that were discussed with relevant hotlinks in the WWW course.

All the pre-service teachers reported their intention to use computers in the classroom with their students in order to enhance teaching and learning (Item 23, Table 1). One student commented that hers was a commitment to creating a new kind of learning environment for all, but particularly remote Indigenous, students. Another student saw that this would occur during her next practicum: " ..I think that I can go to the Web and find out interesting lessons, which is one of my main concerns. Kids sit down and get stuff poured into them that is not interesting." The students' commitment demonstrates a broader consideration of the role that the WWW and email needs to play in school and, as the students' take their understandings home, their communities.

4 Conclusion

Overall, at the end of phase one of the project, there was a favourable response to the introduction of the Internet into the students' Bachelor of Education course. Importantly, the research highlighted a number of issues that the RATEP Academic Coordinator, lecturers, and RATEP Management Committee can consider to help improve the incorporation of the Web and email for improved teaching and learning: technical issues such as the provision of more than one modem per RATEP site; incorporation of assessable items to do with effective searches on the WWW; meaningful use of email and Web discussion forums in various subjects across the degree program; seeing serious play that helps develop WWW procedural skills as part of the course structure; examination of the nature and role of WWW lectures in developing conceptual as well as procedural understanding of the WWW; and creating purposeful "authentic" links between the Internet subjects and their community.

It is argued that the Internet will prove to be an effective tool to combat colonisation. For instance, geographically dispersed Aboriginal communities and Torres Strait Islander communities are able through the Internet to set their own agendas to communicate and consult (network) on issues of mutual concern, such as the current attention concerning land and sea rights claims. In the second phase of the learn-IT research

grant, we conducted an Internet WebBoard International Conference linking Indigenous and non-Indigenous peoples interested in teaching and learning with the Internet. Once analysed, the rich data from this conference should provide further ideas for bridging the information gap, not only to empower, but to provide ownership of the Internet in school, tertiary, and community life.

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MathCAL's Diagnostic Sub-System

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The Internet-Based MathCAL system provides a learning environment for students to practice mathematical problem-solving skills. The system uses Petri nets to represent domain knowledge and keep track of learners' problem-solving behavior. Learners' problem-solving steps are recorded dynamically and stored as Petri net graphs in the system's database. One of the major components of MathCAL is its diagnostic sub-system. The diagnostic sub-system matches a learner's partial solution path against all possible solution paths for the problem and tries to determine which problem-solving procedure the learner is most likely being using. The idea of *critical transitions* as well as other matching mechanism is used to achieve a best guess about the learner's thinking process. This provides the basis for offering guidance to the learner when s/he requests system help. The misconception or missing conception thus identified will enable the system to prescribe necessary tutorials to expose the learner to the concept(s) and guides him/her to practice on selected problems related to the concepts.

Keywords: **Mathematical Problem Solving, Petri Nets**

1 Introduction

MathCAL has been designed as an Internet-based learning system which allows learners to practice mathematical problem-solving skills. It is currently equipped with the knowledge base for solving problems requiring the use of trigonometry. Interested readers may refer to two of our previous papers for detailed description of MathCAL [1,2]. The functions provided by MathCAL, its system architecture and the implementation concerns were fully illustrated in those two papers.

As a problem-solving practicing system, it is essential that MathCAL offers timely and useful help to learners when they encounter difficulties during the interactive sessions. MathCAL tries to provide such assistance in two respects: built-in guidance by the computer and human guidance over Internet with MathCAL-provided communication functions. In this paper we concentrate on the former, that is, MathCAL's newly enhanced built-in diagnostic sub-system. The remainder of this paper is organized as follows: First we use an example to offer a glimpse of the role played by Petri nets in MathCAL. We then describe MathCAL's diagnostic mechanisms, including how it collects experts' problem-solving knowledge and how such knowledge is used to lead the learners out of the impasses they may face. In the end are our concluding remarks.

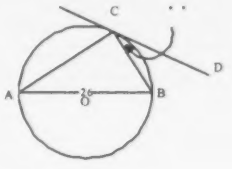
2 A Sample Petri Net Graph Generated by MathCAL

MathCAL uses Petri nets for representing mathematical problem-solving processes, both for recording the correct solution paths for each problem and for dynamically keeping track of users' problem-solving steps. There are three essential symbols in a Petri-net graph, which are *transitions*, *tokens* and *places* [3]. The process of solving a math problem can be modeled as a Petri-Net graph, where mathematical rules

correspond to *transitions*; the conditions for applying a rule are modeled as *places*; and the holding of a condition is represented by placing a *token* in the place corresponding to the condition. In the following we use an example to illustrate how Petri-Nets are used to store problem-solving knowledge.

The Problem Statement:

$\overline{AB}$ is the diameter of the circle with center O. The tangent CD touches the circle at C. • ĐCB = è and cosè = $\frac{12}{13}$. If $\overline{AB}$ =26, calculate the area of △ABC.



When a learner proceeds to solve the above problem, a Petri net graph is generated step by step. A possible graph thus constructed may look like the one shown in Figure 1. The transitions and places used in the graph are explained in Tables 1 and 2.

Table 1. The Transitions Used in Figure 1

Transition	Description
T3	Given the measures of the three sides of a triangle, calculate the trigonometric values.
T8	Given the trigonometric values and the measure of the hypotenuse, calculate the measure of the adjacent side.
T11_1	Calculate the area of a triangle
T17	Theorem: The angle in a semicircle is a right angle.
T18	The angle between a chord and a tangent of a circle equals the angle at the circumference standing on the arc subtended by the chord.

Table 2. The Places Used in Figure 1

Place	Description
P1	A tangent touched the circle at point C
P2	Diameter AB=26
P3	Cos• =12/13
P4	• ĐCB=• •
P5	A tangent CD
P6	• ĀCB is an angle in the semicircle
P7	• Ć of • ĆAB is a right angle
P8	• Ā of • ĆAB =• •
P9	Sin• =5/13
P10	The measure of the adjacent side AC = 24
P11	The area of • ĀBC = 120

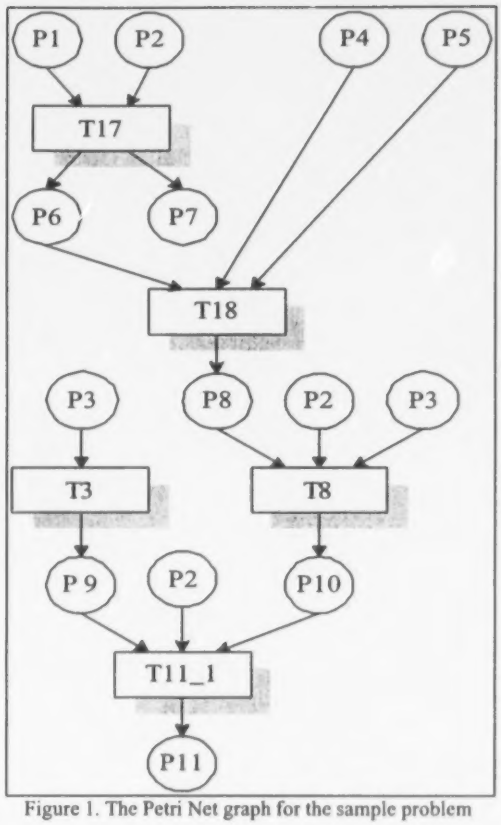


Figure 1. The Petri Net graph for the sample problem

3 How MathCAL's Diagnostic Sub-System Works

As is usually the case, there may be more than one solution for a given problem. For example, there are at least five different solutions for the problem given above. Accordingly, we may have five Petri net graphs associated with the problem, one for each solution. These graphs may be generated by either domain experts or learners. When an expert inserts a problem to MathCAL's problem bank, the system will request that the expert demonstrate how the problem may be solved. It is essential for MathCAL to store at least one correct solution path for each problem so that its diagnostic procedure will function properly. This is necessary because MathCAL needs to compare a learner's partial solution to the correct solution(s) stored when s/he requests system's help in the middle of problem solving. It is thus desirable that MathCAL stores as many solution paths for a problem such that it is capable of finding a solution path that matches most closely with a learner's partial solution. A closest possible match will allow the system to best approximate a learner's thinking process and offer the most suitable guidance. There may also be the case that a learner may successfully solve a problem while his/her solution path is different from any of the stored correct solutions. These new solutions will be detected by MathCAL and added to its database.

The task of identifying a closest match between a learner's partial solution and one of the stored solutions is non-trivial, especially when there are multiple solution paths for the problem. To facilitate this matching process, MathCAL relies on the concept of *critical transitions*. A transition is considered *critical* if the use of it is essential to the derivation of the final result. For any given solution path there may be more than one critical transition involved in the problem-solving process. Besides, different problem-solving methods may result in different critical transitions being identified. Since domain experts know best about what the critical transitions are for solving a particular problem, MathCAL requires that such critical transitions be specified when a new problem is entered into the system's database. For instance, transitions T17 and T18

Towards a Meta-Knowledge Agent: Creating the context for thoughtful instructional systems

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This paper describes a creative approach to electronic courseware authoring. Many online learning systems adopt a generic framework in which cognitive modelling is difficult to achieve. A new CBT package called Cogniware is proposed to bridge this gap by providing a novice-learner with a dynamic instructional device designed to deliver an inclusive learning context. Learners are given the opportunity by this intelligent courseware to identify their cognitive style before embarking on the instructional material. Cogniware will use research findings on the interactive effect of cognitive style and instructional format on the acquisition of complex abstract programming concepts, involving spatial relations and logical reasoning [10], to direct the novice-learner to the instructional format that will best suit their cognitive style. Cogniware will be of interest to educators, cognitive psychologists, communications engineers and computer scientists specialising in computer-human interactions.

Keywords: **Creative learning, educational agent, instructional design, interactive learning environments**

1 Introduction

Reliable mechanisms for courseware design, which provide beneficial flow-ons from research for the training and development sectors [10] are now available. Picking out the important instructional variables (learner's spatial ability, and method of delivery) for some types of instructional outcomes, progresses our ability to provide instructional environments for a broader range of novice-learners. These advancements give the learner a choice of information-transfer-agent, instructional format and instructional event conditions. Too often novice-learners are left to stumble their way through instructional material. We now have the means to deliver customised learning environments. Generic instructional formats often provide too much information, or too little. The meta-knowledge relating to an individual's likely perception of instructional strategies brings our courseware construction into the realm of being truly thoughtful instructional systems' development. In the past, there has been a traditional view that learners adopt a generic approach to make the learning of new abstract concepts meaningful. For instance, the intellectual skill associated with absorbing concepts should be included with the verbal information conveyed during instruction [20]. Cognitive processes involved in learning concepts, are generalization and discrimination [11]. For that reason, individuals generalise from a particular response to learning, to their overall learning experience. Learners look for common attributes that new concepts share with previously encountered ones [11]. However, while still assuming a generic learner cognitive profile, there is now some evidence relating to how an individual's initial mental construct might take the form of a graphical image [5]. That image could serve as a device for mental recognition if the actual object has been seen earlier. Furthermore, mental constructs include the perceptible and non-perceptible attributes of the concept and the cultural meaning given to the name of that concept.

However, there are few examples of research that make a connection between learning abstract computer-programming concepts and graphical-representation as an instructional strategy (see [8]; [9] & [10]. A colour

coding process to trace programming logic flow has been devised by Neufeld, Kusalik & Dobrohoczki [13]; and an interactive system, which traces the hidden activities of a computer-programming interpreter has been developed by Smith [18]. Courseware authoring involves the instructional designer in a complex pedagogical process. First, there must be some understanding of how learners deal with the learning content. Next, is the recognition of the interactive effect of an individual's knowledge processing and cognitive style. Finally, the designer needs to be aware of how the dynamics of the meta-knowledge processing (see Figure:1) impact on intelligent tutoring tools.

2 Dynamics of authoring an intelligent tutoring tool

The McKay [10] research has clearly identified the complexity of the meta-knowledge environment, and has outlined prospects for a customised learning shell. Progress is thus possible in linking research outcomes to actual learning contexts. The advent of computerized courseware dictates a need for innovative instructional strategies to articulate the visual (pictorial) approach to instruction. However, as this work has shown: not all individuals will cope effectively with a *graphical environment*

However, the observed interactive effect of the cognitive style construct [16] and instructional strategy, may be unique to the acquisition of programming concepts. Therefore, researchers/trainers will need to run an extensive pilot study programme to identify the interactive effects within their specific learning domain. In addition, the instructional material does not need to be limited to a textual/graphical comparison, but could be applied to any two or more instructional treatments of any kind. For instance, a structured versus exploratory strategy. Consequently, a special effort is required to reduce the measurable tension between the instructional mechanism (or dynamics of the tutor's view of the topic) and the actual instructional outcomes (or dynamics of the novice-learner's requirement for specific types of knowledge context). Figure:1 shows the interplay between learning and instruction.

Figure 1: Learning Process Dynamics

The Sternberg [19] approach was to concentrate on the basic information processes in analogical reasoning; while Dreyfus & Dreyfus [2] described stages of skill acquisition as five steps from novice to an expert: novice, advanced beginner, competence, proficiency, and expertise. Be that as it may, it was the sequencing of instruction that reflected the beneficial nature of meaningfulness to the act of learning [7]. Therefore, careful consideration needs to be given to the logical sequencing of instructional events to ensure participants are able to progress through the Dreyfus & Dreyfus skill acquisition steps. Intelligent tutoring systems seek to emulate the learning process, providing a novice-learner with a free fall approach to the pedagogy, or a feeling of being lost in hyperspace [4]. Many of the novice's failed attempts to construct the required domain knowledge are alleviated, when the courseware provides advance notification of the instructional content to promote the intended pedagogic framework. Thus the connection can be made between an individual's prior domain knowledge and their internal representation (Figure:1). This instructional device is called an advance organizer. It occasionally makes learning meaningful by relating new knowledge in a parallel fashion, to what is already known outside the content area [15].

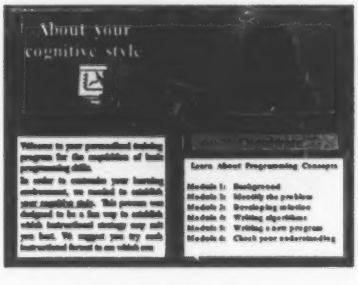
3 Taking a multi-sensory approach

Multi-sensory instruction can improve a student's capacity to learn effectively [1]. This instructional approach maximises the skills brought to the learning task, while minimising the experiences where their ineptitudes are emphasised. Nevertheless, this learning process is often overlooked in the literature, in terms of making new knowledge meaningful by relating to sensory events [17], or to actions already stored in a learner's experiential database (memory). This experiential (human) database is called a sensori-motor database [6]. Accessing this human database is probably the most important method we have for making new knowledge meaningful, during the early years of cognitive development [15]. An instructional strategy can tap into the power of an individual's sensori-motor database, with an innovative textual metaphor, for explaining conditional logic flow to a novice programmer. This textual metaphor describes a common event to support a reflective approach to acquiring the programming concept of conditional logic patterns, thereby encouraging a novice-learner to access their sensori-motor database, to implement a new concept. Experiential leverage for developing the procedural knowledge is gained through providing hands-on experience with example problems. There is a relationship between cognitive level and mental energy consumption in different learning activities [14]. Reading and listening are mentally and physically exhausting with dull and poorly designed material, thereby losing the reader's interest. Furthermore, there is another relationship between cognitive level and suggestive impact, for different kinds of instructional representations [9]. Therefore, designers should be conscious of this and strive to design their learning materials (text and pictures) in the most attractive, and relevant manner possible, so that novice learners are encouraged to process the content (message) on the highest possible cognitive level.

4 Cogniware

Following the premise that a multi-sensori approach is beneficial to learning. Cogniware has been developed using the Electronic Trainer authoring tool from Mindware Creative Inc. At present it consists of a front end module to determine the learner's cognitive style (the CSA [16]), and a choice of instruction method for the acquisition of programming concepts. Cogniware is multi-sensori in the sense that the instructional strategies on offer provide the learning material in a range of alternative instructional conditions. Figure:2 depicts a typical Cogniware screen interface with three instructional formats or separate viewing areas: graphical, textual, and voice. In addition there are cueing mechanisms for guided exploration, such as: directional icons, a learning module name tag, and an advance organizer screen.

Figure 2: Towards a Meta-Knowledge Agent



Cogniware provides the background material on different modes of learning in a textual description interface, while at the same time a voice description can be heard.

4.1 Choice of instructional format

Currently, Cogniware has three types of instructional format available: graphical, textual, and voice (see Figure:2), thereby providing the learner with the format which best suits their cognitive style. However, Cogniware is also flexible enough such that a learner can over-ride the default for the chosen format. Programming metaphors are used as expository instructional strategies. In so doing, they articulate the critical attributes of the concept-to-be-learned [12].

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4.1.1 Textual

There are a number of ways in which we can aid the comprehension of the written word. To overcome one of the central difficulties associated with text processing, Cogniware provides the reader with the best possible means to select important information from the text [3]. Hotwords are included as pedagogical cues to navigate a novice-learner through a new concept. Text should not be considered as a flat structure, where all ideas are expressed with equal importance. The Cogniware text is therefore a highly structured communication tool, in which ideas are expressed hierarchically, where certain parts of the message can receive more attention than others. As a consequence, particular display techniques enable the reader to focus on the full context of the message by selecting the important issues without being overwhelmed by poorly structured text.

4.1.2 Graphical

Graphical metaphors used by Cogniware were chosen for their recognisable and distinguishing (or salient) features, to depict each programming concept to be learned. These visual metaphors serve to elicit prior experiential knowledge, enabling the learner to recognise the distinguishing features of the new concept, and to interpret the instructional context without specific prior learning.

4.1.3 Voice

The learner can view the video interface to hear a verbal description of the programming metaphors. Advice and reassurance is also provided to ensure maximum coverage of the multi-sensori platform. Voice directions for dealing with the CBT navigation are designed to reduce the cognitive effort required in dealing with the complexities of multi-media instruction. Reminders can be seen as a useful technique to keep the novice-learner on track. It is intended that demonstration video clips will be included in future releases of Cogniware to extend the multi-sensori capability.

5 Conclusions

Cogniware represents a creative approach to electronic courseware authoring. The sound instructional design foundation upon which this courseware is built, draws on the research conducted by Merrill's ID_2 team at Utah State University, USA, and recent research by McKay & Garner [9]. The latter research provided the experimental findings to link the important work on the Cognitive Styles Construct carried out at Birmingham University, UK , by Riding [16] with the effectiveness of various instructional formats. Cogniware was authored using The Electronic Trainer providing the ideal knowledge based framework for authoring electronic courseware. Online learning systems adopting a generic framework reveal that cognitive modelling is difficult to achieve. It is proposed that Cogniware bridges this gap by providing a novice-learner with a dynamic instructional device designed to deliver an inclusive rather than exclusive learning context. At the nexus of this CBT is the ability afforded to learners to identify their cognitive style before engaging with the multi-sensori instructional devices, allowing selection of an optimal instructional format. Cogniware will be of interest to educators, cognitive psychologists, communications engineers and computer scientists specialising in computer-human interactions. Researchers can now provide a better understanding of the interactive effects of the cognitive style construct and instructional format on the acquisition of abstract concepts, involving spatial relations and logical reasoning [10].

Educational researchers are reminded to work towards ensuring their instruction works for people rather than ensuring their instruction works for the technology.

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Network Usage Survey and Its Analysis with Related Factors between University Students and Occupational Groups in Taiwan

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This research was to investigate the current situation of computer network usage, frequency and purposes between university students and occupational groups in Taiwan. The research also analyzed the influences of its related factors on computer network usage, such as computer experience background, the attitudes toward computers, personality, aptitudes, critical thinking ability, academic achievement and so on. The subjects of university students were sampled from the Soochow University. The subjects of occupational groups were sampled from various occupations. The Computer Experience Background Scale and the Computer Attitude Scale were conducted by author for this research. Lai' s Personality Scale, Differential Aptitude Tests and Critical Thinking Appraisal are three published tests selected appropriately by the author and used for the research purposes. Academic achievement in the research was based on the students GPA.

According to the computer network usage of university students, 150 students were sampled in 1997. The network usage was classified into three types of purposes: (1) information searching, (2) BBS, (3) e-mail. The findings were that the students used computer network for searching information the most frequently, then for BBS, for e-mail the least frequently. Besides, the male students significantly used computer network more frequently than the female students, especially for the usage of information searching and e-mail purposes. About computer experience background and the attitudes toward computers, the students who have more computer experience background and who have more positive attitudes toward computers significantly used computer network more frequently where the influences from computer experience background was larger than the influences from computer attitudes.

Since the subjects from the university students can be arranged and administered by the Lai' s Personality Scale, Differential Aptitude Tests and the Critical Thinking Appraisal, and their GPA can be retrieved from the university, therefore, the relationship between computer network usage and personality, aptitudes or critical thinking ability were analyzed. The findings of the Lai' s Personality Scale were that the students who were more objective, less depressed, and less nervous significantly used computer network for information searching purposes more frequently. The students who were

more social types of personality significantly used computer network for BBS purposes more frequently. The students who were more worry and distress significantly used computer network for e-mail purposes more frequently. The Differential Aptitude Tests was found that the aptitudes of arithmetic and abstract reasoning were significantly positively correlated with the frequency of computer network usage for BBS purposes. None of critical thinking abilities was significantly related to the computer network usage. The students' GPA was not found to be significantly related to the computer network usage either.

Since we sampled 110 university students for the same survey again in 2000, the changes of the computer network usage by time sequence were investigated in this research. It was found that no matter the usage of information searching, BBS, or e-mail purposes, the university students in 2000 have significantly more frequency in using computer network than the students in 1997. The university students in 2000 yielded significantly more computer experience background than did the students in 1997 too. However, for the attitudes towards computers, the university students in 2000 did not make significantly difference from the students in 1997. These results indicated that university students always respected the importance of computers in their lives. They significantly used computer network more and more by years. As a matter of fact, computer network will be the main tool to get survived in the future hi-tech world.

For surveying computer network usage of occupational groups, 115 adults were sampled in 1999. It was found that they significantly used computer network for information searching and e-mail more frequently than for BBS. No gender effect was found to be related to the usage of computer network. In addition, the more computer experience background the occupational groups have, the more significantly frequently they used computer network. However, their attitudes toward computers were not significantly related to the computer network usage. The results of age stages showed that the elder people significantly used computer network less frequently than the younger people.

General speaking, the occupational groups used computer network for e-mail purposes significantly more frequently but for BBS significantly less frequently than did the university students. The occupational groups significantly yielded more computer experiences than did the university students. It has to be mentioned here that since we sampled university students and occupational groups in different years, these results might confounded with the time effects. Further research and experimental design were suggested to verify these problems.

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A Real-time Handwriting Communication System for Distance Education[+]

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1 Introduction

In this paper we present the design and implementation of a handwriting communication system for real-time graphical information exchange. This system provides an environment for a user to write and erase messages on a computer screen using a light pen or a mouse and to transmit the handwriting message to another user on the Internet in real time. The communication techniques employed for the system include the basic client-server model and peer-to-peer model. The client-server model is mainly for sending handwriting information using the world wide web. The peer-to-peer model, however, is aimed at real-time communications between two end users on the network to conduct instant dialogues. The system is implemented using Java . It can be integrated into many different applications such as collaborative learning, on-line discussions, and distance education.

2 Communication Models

A handwriting communication system may be implemented using a client-server or a peer-to-peer model. Each model has its cons and pros. The client-server model, in which the client sends requests to the server and the server responds to the request [3], works well in situations when immediate responses are not necessary. For a real-time instant dialogue or information exchange, however, the client-server model alone is somewhat restrictive due to its limited degree of interactivity. To achieve a full degree of interactivity for this type of applications, a peer-to-peer model that allows for full duplex real-time communications is more appropriate, since the two end users of the system may send and receive information at the same time, roughly speaking.

In addition to communication models, we must also take into account the nature of the communication protocols and decide which to use. Information exchange carried over the Internet normally requires support from either TCP or UDP, which are the two protocols operated at the transport layer in the TCP/IP protocol suite [1]. When TCP is employed the information is sent as a data stream, similar to a telephone conversation. Since TCP requires a connection setup prior to transferring data, it incurs an initial time delay. UDP, on the other hand, does not require such a connection setup. However, the delivery of datagram packets, which are independent data units sent individually from the source to the destination, is not guaranteed. Datagram packets may arrive out of order too. For textual information, UDP may not be a bad choice because the user normally can tolerate, to certain degree, occasional loss of packets or misplaced textual data. In our handwriting system, the handwritten information is represented as numerical data which are sensitive to the loss of any single bit of information, therefore, TCP is our natural choice.

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3 System Design

Our design philosophy for the development of the handwriting portion centers around the following principles: interactivity, functionality, reliability, user-friendliness, and portability. A handwriting communication system must possess two important capabilities. The first is the ability to support the writing by a light pen, or a mouse if such a pen is unavailable, and the display of the handwritten data. The second capability should allow users to transmit and receive handwritten data from the network. To achieve these goals, a friendly graphical user interface, which requires the use of abstract windowing toolkit and event handling, is a necessity. In order to make the system a useful communication tool on the Internet, it must support both textual and graphical information exchanges. The system must also provide functions for users to overwrite or modify handwritten message received over the network. In addition, the programming language used for implementation must be platform independent so that the system can be easily ported to other machines with different operating systems.

4 Description of the System and its Applications to Distance Education

As mentioned earlier, we use Java [2, 4] as the programming language and TCP as the transport protocol for transferring handwritten data in our current client-server communication system. A graphical user interface consisting of buttons, radio check boxes, and a handwriting area, as well as the operations associated with the interface have been developed using the abstract windowing toolkit. All main tasks of the system are invoked from within the event handling functions. Our system currently allows users on the Internet to exercise handwriting from within a web page that contains the client code and send the information to the server that accepts the handwritten data. It can also be used to enhance online presentations over the Internet. This is due to the fact that the system allows users to perform handwriting directly on the specified writing area in a web page. By putting the presentation material inside the handwriting area, it is possible to add notes, make corrections, highlight important subjects on the spot during the course of the presentation.

The handwriting communication system has many applications in distance education and on-line collaborative learning. It can be used by an instructor to deliver on-line lectures via the web; the instructor may use one part of the screen to present prepared presentations and another part to highlight the important points of his/her presentation using a light pen. It can be used by fellow students in different locations to solve problems collaboratively and work on team projects. In addition, the instructor and students can use it to conduct on-line class discussions and answer student's questions by employing the communication capability.

5 Conclusions

In this article, we have presented the basic approaches, design considerations, and implementation of a real-time handwriting communication system on the Internet as well as its applications to on-line education. Our design philosophy centers around functionality, interactivity, portability, and user friendliness.

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Simulating Engineering Professional Practice Using an Interactive Web-based Resource: A Virtual Engineering Consultancy Company (VECC)

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A well designed PBL environment can assist and support students in building heuristics that will enhance their ability to solve problems in the real world. Problem based learning is situated in the context of a meaningful 'real world' based environment which draws on 'real variables' without the 'risk factor' normally associated with everyday practice. It poses an ill-structured, 'real world' based problem which drives the learning. Posing the problem before learning takes place provides relevance, challenge and interest, and is a powerful motivational strategy. This paper reports on the development of an on-line, problem based learning (PBL) environment (the VECC) in which students develop and practice engineering consultancy skills. Evaluation of the pilot implementation with 3rd year Engineering students at the University of Wollongong is briefly outlined. The VECC models the skills and processes of an 'expert consultant' "a professional engineer" in the field of Heat Transfer within a supported learning environment so that 'novice' student's develop appropriate problem solving skills vital for their later engineering practice. The power of a web-based environment to provide platform which supports both synchronous and asynchronous computer mediated communication enables students to interact with a virtual client in an environment which is "safe" and highly flexible.

Key Words: **Problem based learning, virtual environments, problem solving, consultancy, virtual client.**

1 Introduction

Traditionally, students graduating from engineering courses have had limited if any exposure to the wide range of practical skills centred on 'real world' contextualized problem solving and client contact which engineers must have 'in the filed' to be successful. There are many reasons for this, often based in the pedagogical approach characteristic of the institution in which they are trained. Providing a 'risk free' and cost effective environment in which students may develop and practice such skills is perhaps the other major influencing factor. A possible solution to this impasse is to provide a means of developing and practicing these skills using simulated environments.

Universities and other tertiary institutions throughout the world are rushing to embrace alternative delivery methods, particularly those that utilise the versatility and power of the World Wide Web. This is in response to the globalisation of education, the recognition of the need to provide mechanisms which will maximise opportunities for and support life long learning and the need to expand the boundaries to encompass educational experiences which are set in 'real world' contexts. The scope and boundaries for what is possible in such environments is limited only by the imagination of developers and the limitations of the web in its

present form. The web is a dynamic medium whose boundaries are being extended almost daily.

Further, suggests Burnett (1997) [3], the use of the Web will continue to expand as it becomes more stable, easier to use and more accessible to everyone. What we are learning from using the Web today will provide the confidence and expertise to take advantage of the advances in its technology. Now is the time according to Alexander (1995) [1] to stop focussing on the technology itself and to start focussing on what students are to learn, and the best way for them to achieve these learning objectives. This indeed was one of the key issues of "Secrets of On-line Teaching".

In recent times many of these institutions have experimented with the use of on-line delivery with the purpose in mind of extending access to educational experiences to a wider audience on a any time, any place basis. In many cases, the results have been less than satisfactory and have fallen short of student expectations for a number of reasons. The problem is exacerbated by a number of factors. These include: time and funding restraints; the often unjustified self perception of expertise in the field and the mistaken belief by many that, putting a subject or teaching resource on-line involves little more than providing content as a web based document. Given that this situation will probably not change in the foreseeable future, how can we as teachers/designers/developers ensure that our web-based resources are effective, efficient and supportive life long learning?

"An understanding of the techniques and protocols of on-line teaching and learning and the processes of both the design of new and the conversion of pre-existing resources has become essential for academics, as universities throughout the world embrace alternative delivery methods in response to the globalisation of education." Corderoy & Lefoe (1997) [5]

2 Design Issues for On-line learning Environments

An integrated online environment such as the VEEC provides a set of tools, systems, procedures and documentation that facilitates the occurrence of any or all parts of the learning experience using some form of computer mediated communication. Moving to web based delivery of a subject or any aspect of that subject will carry with it the need for both the designers and the teachers to recognize and act on the many issues associated with such environments.

The logistics of setting up and running this type learning experience mirrors the issues that are addressed in setting up any on-line course. In general the issues can be identified as belonging to three basic categories identified in any on-line learning environment, namely technical support, pedagogical and equity issues.

Some of the more important issues include:

- Interface easy to use and navigate
- Bandwidth limitations
- Security and submission of work
- Equity of access to the technology
- Unfamiliar format for some - provide time to adjust
- Lecturer's participation - make regular contact - ensure all have accessed by a certain time
- Lecturer's willingness to moderate/facilitate collaboration
- Consider cultural differences
- Work load changes for lecturer
- Perceived inequality of experience

Of these, the authors single out technology problems including access, interaction and communication and workload as being crucial to successful learning outcomes for students working in on-line environments

2.1 Technology

The students need to be 'trained' in the basic use and operation of the technology before they start and this is often best achieved by 'face to face' instruction at the start of session. As a good rule of thumb, problems are minimised by designing to the 'lowest common denominator' in terms of available technology. Related to this aspect is the equity issue of student access.

2.2 Interaction/Student Participation and Enthusiasm

One of the most significant challenges for those using on-line teaching environments is the 'silent student'. Ensuring that the students engage in the learning is closely related to the degree of interactivity fostered between students and their peers as well as between the students and the instructor. Success in the latter is dependent upon an instructors commitment to providing 'rapid feedback' to submitted tasks and posed questions as well as regular personal 'checking in' on-line. Such commitment provides an incentive for all students to be active and enthusiastic.

2.3 Resources/Time and Workload

There is a need to consider carefully the design and structuring of on-line environments, particularly those which already exist in a traditional format. Content cannot be simply 'placed on the web'. Time and effort must be spent in considering the resources and structure needed to best present the materials in the 'new environment'. Developing materials for on-line delivery is not an easy or short process. Both the teacher and the students must be committed to accepting a greater workload as a trade-off for the value of working in an environments which mirrors 'real life' situations and skills application.

3 Developing the VECC

The VEEC has been developed on a sound pedagogical basis using a team approach, utilising the specific skills of each team member. The Faculty of Engineering and the design/development team at the Centre for Educational Development and Resources at the University of Wollongong, Australia, have been involved in the development of a prototype over the past 18 months. The VECC is a highly interactive and innovative web based simulated consulting environment, based in the 'real world' problems and processes usually associated with the task of a professional consulting engineer in the area of Heat Transfer. It provides an environment which models the 'experts' heuristic's for solving the problem, facilitating the development of an appreciation and understanding of the application of the skills and processes needed in a real world consultancy in the 'novice' student. The result will be a graduate engineer who is better prepared for the 'real world' engineering practice.

This flexible, web delivered, student-centred resource provides not only training in specific technical area, but also orientation and experience in professional practice. This type of advanced training has been demonstrated to have significant benefits to students entering the workforce. Ryan *et al.*, (1996) [8]

The framework of the VECC package is modelled on the resources that one finds in a real engineering consultancy office. The consultant in such an office will have developed an expertise in their chosen field - in this case Heat Transfer - and will also undertake continual professional development. This CAL learning environment will therefore foster a positive attitude in students towards lifelong learning. Candy *et al.*, (1994) [4]

The Industrial Problem Solving Assignments are the main educational vehicle for building students' confidence in tackling real world situations and complex tasks. This feature differentiates the VECC from other engineering CAL packages. To quote Laurillard (1993) [6], "we cannot separate knowledge to be learned from the situations in which it is used". In the VECC, students will immediately see the relevance of the engineering theory to be used, since they must actively search for the appropriate theoretical model. That search is the same process the student will eventually use as a practicing professional engineer.

When using this resource the student role-plays a consultant who carries out all the managerial and technical tasks required to expedite a number of high-level Industrial Problem Solving Assignments. This problem-based learning approach "confronts the students" Boud *et al.*, (1991) [2] with 'real world' based ill-structured problems and scenarios which provide a stimulus for learning and in so doing "encourages the students to take a deeper approach to learning". Ramsden (1992) [7]. The PBL approach enriches the learning outcomes by simultaneously developing higher order thinking skills and disciplinary specific knowledge bases and skills. It promotes the student to the active 'practitioners' role in the process.

The consultant's activities include:

- negotiating with the client on cost and timetabling of the consultant's services
- obtaining the client's technical brief and tendering for the project
- sourcing technical information such as plant dimensions
- making on-site measurements of temperatures or other parameters
- student-centred learning through the Computer Aided Learning (CAL) module integral to the Virtual Engineering Consultancy Company
- simulation of real-life problems using a toolbox of simulation resources.

4 Expected Outcomes

The most significant expected outcomes for students using this web-based package include:

- A PBL based CAL resource that provides Engineering students with training in professional practice as consultants in Heat Transfer Engineering through 'virtual access' to 'virtual clients'.
- The simulated 'real world' environment that the web provides will provide them with a better understanding not only of the processes involved in professional Engineering practice but also the relationship between the Engineers and client.
- Improved effectiveness of delivery to a diverse student population of full-time, part-time and off-campus students.
- Improved skills in collaborative working and negotiation.
- Improved attractiveness of University of Wollongong Engineering graduates to potential employers.
- Flexibility in terms of meeting the course requirements with regard to time and place and individual learning styles.
- Improved opportunity for students to be active members of the cohort in all facets of the course.

5 The Pilot Virtual Engineering Consultancy Company (VECC)

To date the fundamental structure of the VECC and a substantial number of software resources (including interactive Heat Transfer simulations) have been developed. The complete package will eventually contain in excess of 30 simulations which will support and develop the students understanding and proficiency in aspects of Heat Transfer including: furnace insulation; steel quenching; conduction and boiling heat transfer.

Extensive work has also been carried out on the structuring of the 'theory section' of the package. Consideration has been given the 'chunking' of this considerable resource so as to provide a meaningful resource for the students while at the same time being 'easily accessible' within a web based environment.

The centre of the VECC resource is the consultant's office (Fig 1) that models a typical engineering office in the real world and has facilities including:

Fig 1: The VECC Consultancy Office

In summary, the VECC resource will eventually comprise three main Modules;

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- **Training (CAL) Module** - the student uses resources such as simulations, text-based material, videos, animations, etc to learn the fundamentals of Heat Transfer theory.

- **Trouble-shooting Module** - here the student has to solve challenging real-life problems that are far more in-depth than conventional engineering assignments. In an example already developed, the student's client is a corporation that has just built and commissioned a large hydrogen production furnace. The furnace is overheating and the student must find out why, suggest remedial measures and act as an expert witness in a court case.

- **Design Module** - Students design a number of pieces of thermal equipment to satisfy a specification from their client. Examples will include a transistor heat sink and car radiator. The detailed design of thermal equipment is not a topic normally covered in an undergraduate course on Heat Transfer perhaps because it requires a problem-based learning approach and yet it can be one of the most rewarding aspects of an engineering student's study.

- A **project management whiteboard** that will be automatically updated as a student progresses through the study programme.

- A **laptop computer** which is the virtual gateway to the web and provides contact with the clients (the lecturer) for each project, resources external to the VECC and the brief containing full technical details. (Appendix 1)

- A **video monitor** for access to video clips of site visits, illustrative fluid visualisation experiments, lecture presentations, etc.

- A **desktop computer** which represents a powerful computing resource where the heat transfer simulations are located. These already include four unique simulations of important conduction heat transfer situations. Each simulation deals with a real world problem and will be used as part of the consultant's exploration of the case studies.

- A **telephone** for initial contact with the consultant's clients achieved using an audio track.Hello, Chris Garbutt here. I'm the Engineering Manager of Heat Treat TM. Our company deals with a large variety of construction projects involving thermal and chemical processing. We struck some heat transfer problems with one of our projects involving a furnace that is not operating as was planned and we're asking your consultancy firm, along with others, to tender for a trouble shooting role in fixing the problem.

  If you are interested in taking on this challenging consultancy, a brief containing full technical details of the project at our company's web site can be accessed through your laptop computer. I hope you can help us out. Please E-mail me if you have any queries. Bye for now.

- A **virtual library** of books which is the link into the CAL module where the student explores the topic of Heat Transfer through the problem-based learning approach of the VECC.

6 Pilot Evaluation

Students who took part in the pilot implementation had access to a limited prototype version of the 'complete' site. At this stage of its development, some of the segments of the VECC exist as discrete units that are independent of the overall structure. It was expected that this may cause some navigational/continuity problems for some students, however early anecdotal evidence collected from the students seems to suggest that this was not the case. Approximately 80 3rd year engineering students (20 groups comprising 3 or 4 students each) used the VECC to complete a major assignment during semester 1. Each group consulted in various degrees with the client using the E-mail link, used the various resources available within the consultancy office to support their investigations and develop their 'solutions' to the 'posed problem'.

Data collected during this pilot includes: student interviews and comments including a special forum where technical issues and the learning processes were discussed; lecturer's observations; archived E-mail communication between the lecturer and students and; individual marks awarded to students together with the lecturer's 'quality of answer' evaluation.

6.1 The Students' perceptions

Comments made by students to the lecturer include:

- convenient and easy to use;
- provides for flexibility in their study schedules;
- provides access to a greater richness of resources;
- helped them develop an understanding of the issues critical to client management;
- motivating;
- provides time to consider actions and issues
- allowed them to develop collaborative networks
- use of a real world problem put the theoretical concepts learned and the analytical skills developed into the context of their future activities as professional engineers and;
- comfortable working in this delivery mode.

6.2 The Lecturers' perceptions

Although at this early stage in development there is no longitudinal data for comparison, the lecturer is confident that data to be collected during the continued development and use of the VECC will support and re-enforce observations made so far including:

- overall performance of the majority of groups is better than past years, not just in terms of the overall mark but in the quality of the answers;
- role play appears to have contributed to a deeper understanding of the problem and possible solutions and enriched the learning experience;
- there has been no change in the completion rate, the number of students 'opting out' is about the same as usual;
- students who took full advantage of this support by contacting the 'client' (lecturer) performed better than those who did not;
- seems to be a time efficient way of presenting both the technical information and the processes involved in consultancy in a richer environment;
- flexibility for both students and lecturer is a 'real plus' and;
- the students seemed to be more motivated and this is reflected in their willingness to explore the resource base fully, developing better quality answers.

7 Future directions

There are several issues unique to technology based delivery which need to be investigated with respect to the VECC. The student groups had minimal exposure to the 'structure' and process of the VECC in lectures. Did this add to the cognitive load placed on them so that unnecessary effort was expended on learning about the system, rather than from it? Experience shows that with poor design, there can be an enormous increase in the cognitive load for students and the result is a poorer outcome than expected. To address this, it is envisaged that an extensive help system will be provided within the package. Specific lab sessions prior to using the system will also be run to allow students time to become familiar with the package. Such 'user support' mechanisms are an essential part of complex learning systems and it is essential that all students avail themselves of it. Ensuring that they do is one of the keys to facilitating useful student interaction with the learning environment. The issue of preferred learning styles and the 'students' fit' to the delivery mode needs to be explored.

8 Conclusion

Flexible modes of delivery such as Web based instruction can provide an effective means of addressing the problems of increasing student demands, decreasing funds, the need to establish a presence in the

international market place and rapid technological change. The rapid rise in the development of sophisticated and improved technologies has been the driving force behind the widespread embracing of the concept of flexible delivery and the application of the many and varied tools upon which it is based in the field of education and life long learning. The VECC is a web based flexible learning tool which provides students with 'real world' based experiences in professional practice. Early indications suggest that students are benefiting from this virtual consultancy learning environment which uses a problem based learning approach to develop the skills which are vital to engineering practice in the real world.

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Appendix 1

YOUR BRIEF

Heat Loss Calculations

If you choose to accept this assignment HeatTreat requires you to:

- to calculate the total heat loss from the furnace walls and roof (as a first approximation assume a outside surface heat transfer coefficient to be $20 W/m^2$ including both convection and radiation heat transfer)
- to calculate the interface temperature between the Zirconia Blanket and the Mineral Wool to ensure that the latter does not overheat.

Surface Temperatures

The client has measured outside temperatures on the outside of the furnace to be in the range of 105 to 170°C. These are potentially very hazardous. You must perform the following tasks. A map of some of the surface temperature measurements is shown below.

Outside Wall Temperatures

Furnace level	1	2	3	4	5	Floor
Mean outside surface temp (°C)	75	64	68	70	68	52

a) Carry out a sensitivity analysis of one of the wall the surface temperatures to the outside heat transfer coefficient (calculate the expected radiation heat transfer coefficient assuming emissivity, $\varepsilon = 1$, and then vary the convection heat transfer coefficient in a range that would be expected under normal weather conditions ie between 5 and $20 W/m^2 K$, say).

b) Determine whether the firebrick insulation shown in the design drawings is likely to have been put in place correctly (if the insulation has not been properly installed legal action may be taken against the insulation installation sub-contractors). Assume the flue duct wall temperature is equal to the gas temperature of Section 6 of the furnace.

c) Recommend a solution to these high surface temperatures problems. Some possibilities include:
Add extra insulation to outside of furnace (you must calculate how much must be added and whether the resulting temperature of the structural steel is within acceptable limits).
Shut down furnace and replace internal insulation in problem areas (very much a last resort represents a very high cost option).?

Summarise your recommendations.

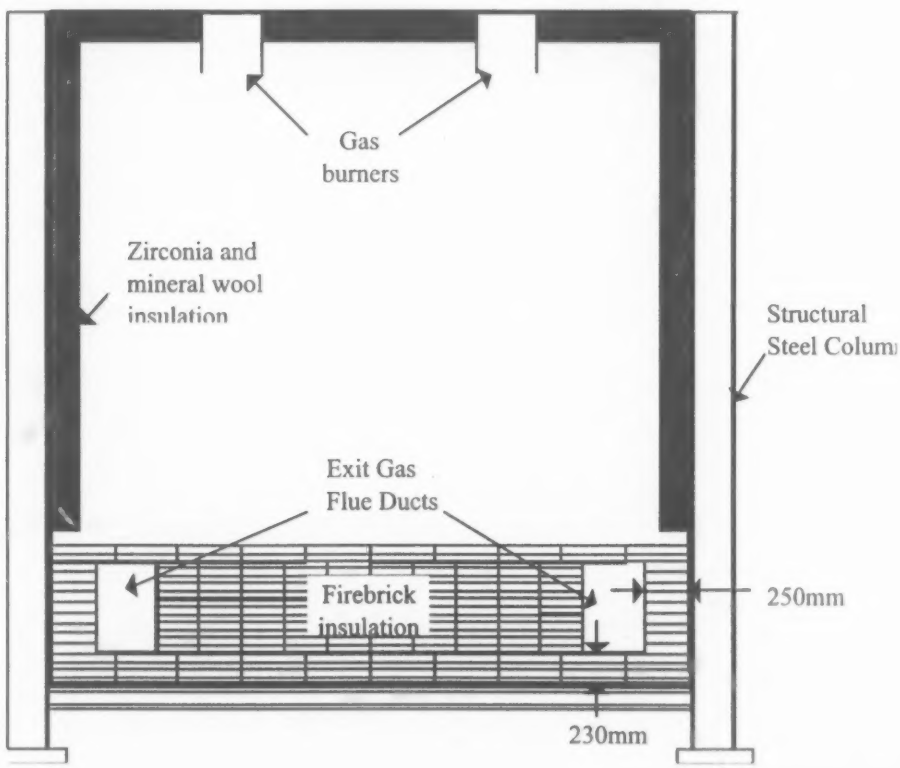
Further information

It is up to you to source any further information that is required. Local sources of information include:

- the training module "Conduction Heat Transfer" on your desk
- thermophysical data of various materials in the appendix of "Conduction Heat Transfer"
- simulations and video footage available on the desktop computer and video screen.

Remember that obtaining relevant information is often a critical task in high level engineering work and decision making.

If you require specific information on this Brief please contact your client at the following E-mail address. Paul_Cooper@uow.edu.au.



Layout of furnace insulation and structural steel.

Students' thinking processes when learning with computer-assisted mass lectures.

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This paper presents findings from a research project that examined students' thinking during mass lectures that utilized interactive multimedia (IMM). The data were obtained from six second year Thai medical students via stimulated-recall interviews. The reported thinking (or mediating) processes engaged in by the students during the mass lectures that related to the academic content of the physiology subject are detailed and discussed. We identified 18 different types of thinking skills including generating, anticipating/predicting, linking, metacognition, analyzing, and categorizing. These ranged from a high usage frequency (generating) to a low usage frequency (categorizing). Being able to understand such student thinking may result in more effective use of IMM in mass lectures. The data are also compared with studies that provided students' reported thinking processes when studying with the WWW, IMM, and text-based material. The significant differences in the mediating processes between using IMM in computer-assisted mass lectures, where the students did not directly interact with the IMM, and hands-on use of IMM, the WWW, and text-based material are discussed.

Keywords: **Thinking skills, Computer-assisted mass lecture, IMM, medical education, Thai medical students**

1 Introduction

There is increasing use of IMM in mass lectures in universities for teaching and learning. Yet IMM supported lectures do not guarantee better content learning or higher-order thinking than do traditional instruction methods. There is much research and literature concerning instructional design, the characteristics of IMM, and learning: for instance, the use of educational technology [1] and the effects of colors [2], animations [3], and interactivity [4]. Research has neglected how students engaged with the new technology in lectures. The research by Nowaczyk, Santos, and Patton [5] examined student perceptions of various characteristics of multimedia such as color transparencies, video, and PowerPoint in tutorials and mass lectures. However, they did not investigate students' thinking processes about the academic content. The research by Faraday and Sutcliffe [6] examined visual attention and comprehension of multimedia presentations. Research by Putt, Henderson, and Patching [7] and Henderson, Putt, Ainge, and Coombs [8] examined learners' mediating process about the academic content of IMM and WWW courseware, respectively. However, these did not focus on an IMM mass lecture context.

Studies report that IMM can be effective in encouraging higher order thinking skills when learners work with IMM individually or, better still, in pairs or small groups [9, 10, 11]. However, in a mass lecture, the IMM is controlled by the lecturer. Learners play a passive-receiver role. Are they focused on the content? What sort of thinking about the content do they engage in?

Heeding current literature in the field [1, 12, 13], the study does not aim to ascertain whether learningwith

IMM supported lectures produces better learning or test outcomes than traditional lectures. Rather, it utilizes qualitative methodologies to ascertain the students' thinking skills as they learned in the authentic context of a lecture theatre. Thus the study sought to:

(a) identify and categorize the thoughts concerning the content of the IMM supported lectures that were reported by the students;

(b) compare the mediating processes reported in the computer-assisted mass lecture study with those reported in research which identified the reported mediating processes that occurred in three studies where students had hands-on use of IMM software, WWW courseware, and text-based materials respectively; and

(c) with respect to (b), evaluate our hypothesis that the type of interaction with the learning materials would be a significant factor, that is, the lack of direct manipulation of the learning materials would result in lower percentage frequencies of reported mediating processes (our study) compared with those reported in the other studies that had direct hands-on interaction.

2 Methodology

Much existing research data regarding the efficacy of computer mediated environments is anchored in the process-product paradigm. The paradigm is based on the assumption that instructional stimuli give rise to learning outcomes. Recognition of the simplistic nature of this general cause-effect paradigm when applied in education, led to the adoption of the mediating process paradigm that focuses on student thought processes that mediate, or come between, instructional stimuli (the IMM supported lecture) and learning outcomes [14]. Mediating processes can be viewed as the fine-grained elements of cognition through which, and by which, learning outcomes are realized. Thus, learning outcomes are the function of the mediating processes activated by instructional tasks and other learning activities. Salomon [11] describes the contrast between analytic research that is focused on isolating effective instructional treatments and systemic research focused on understanding how instructional treatments work in practice. This study embraced systemic research focussing on the sorts of thinking that tertiary students engaged in during IMM supported lectures.

It is a qualitative study utilising stimulated recall interviews to ascertain students' thinking in authentic contexts. Learning is related to the quality and quantity of thinking undertaken by learners [15]. To categorize and tabulate students thinking skills, a process-tracing methodology is utilized. It involves appropriate self-reporting techniques through using a video to stimulate recall of cognitive processes engaged in during a learning/study session. The stimulated recall interview technique follows strict guidelines [14]. Triggered by such things as the students' non-verbal actions or what is appearing on the computer screen, non-leading questions are asked, such as: "You seemed to frown; can you tell me what you were thinking?" and, in order to confirm that the reported thought occurred during the learning session and not while being interviewed, "Did you think that then or just now?" Both the interviewer and students can stop the video when they believe something is significant and, for the student, when the video triggers a thought that he/she had had during the initial study session. This method has been used in different settings with different mediums and with individuals, pairs, and small groups [7, 8, 16, 17, 18].

2.1 Context, Participants and Data collection

The research context and methodology capitalize on authenticity [11]. The students' thinking processes were obtained in realistic, ecologically-valid situations as the data were collected from students working in their regular environment. Thus for the current study, the research was conducted with a physiology class in a mass lecture theatre, Faculty of Medicine Siriraj hospital, Mahidol University, Bangkok, Thailand. The lecturer used A.D.A.M., The interactive physiology-muscular system [19] in the one hour lectures. Two lecture sessions were video recorded. Six students volunteered to participate in the stimulated-recall interviews. There were four males and two females with ages ranging from 17 to 19 years. They were in the third semester of a six year Medical degree. The six participants self selected into 3 pairs, 2 male pairs and 1 female pair. Working in pairs was the favored study practice of these Thai medical students. The first male pair was interviewed after the first lecture session; the others after the second lecture session. The content of both lectures was the same topic and used the same IMM. All six participants attended both lectures.

The interviews were conducted with one pair at a time. The interviewer and each pair of participants together viewed a videotape of the lecture and a synchronized computer screen showing the A.D.A.M. IMM software that was used in the lecture. The video picture included the lecturer's verbal and non-verbal behaviors and the content of the computer-assisted lecture. The computer screen showed the A.D.A.M. IMM

software content which appeared on the videotape. Both videotape and computer screen facilitated the participant's recall and verbalization of their thinking during the lecture. The three stimulated recall interviews, one hour duration for each interview, were conducted immediately after the lecture sessions and were audio taped for later transcription and analysis.

3 Results

From the interview transcripts of the students' stimulated recall interviews, their thinking skills were identified, categorized, and then analyzed. Both authors together identified the thoughts from the first transcript. The others, they did individually. Then the data from each researcher were compared and discussed. Consensus was achieved when disagreement occurred. The data that were considered invalid, such as student's thinking that did not occur during the study session, the reports of students' activities that were not related to their thinking, and answers where the interviewer had led the student, were identified and discarded. Only students' thinking that occurred during the study session were identified as useable data.

The students' thinking data reported by participants were classified according to the mediating processes identified by Henderson, et al. [8]. The 18 mediating processes identified in our study are listed in Table 1 which provides a definition for each thinking skill and a clarifying example of each from the data.

Type	Description	Example
	Mental activity in which a student -	
Affect	reports feelings aroused by content during study	"He [the lecturer] clicked A. I was glad. My answer was correct."
Analyzing	Reduce, breaks down whole (e.g., problem, task) into parts	"I've learned that content. There were some new parts adding to it. The rest was old."
Anticipation	predicts or states expectations that problem, question, or textual feature will be encountered; wonders about: the possibility of an event, relevance of material, content	" He [the lecturer] was talking about timing. So, I thought ahead that it must higher. And when stimulated, a bit slower - it would be lower."
Applying	Considers the use of an idea, tactic in a different context.	"When I saw the clearer image, I thought they should use this technique in the textbook because it can't use animation."
Categorization	Sorts items, ideas, skills into different groups	"I thought I already noted this as asynchronous."
Comparison	identifies similarities, differences between two statements, concepts, models, situations, ideas, theories, points-of-view, etc.	"From the graph shown on screen, I thought it would appear in another way."
Confirmation	judges that ideas in text support one's own beliefs, practices, tactics	"When he [the lecturer] clicked, I just thought that one is correct."
Deduction	reasoning process by which a specific conclusion necessarily follows from a set of general premises	"I felt the image doesn't look real because the vesicle [4small bags within a larger bag] has just 4 bags and the water filled this space."
Deliberation	engages in "thinking" about a topic, prose segment, etc. (type of thinking not disclosed)	"I was thinking about the question."
Diagnosis	identifies strengths and weaknesses in idea, strategies, points-of-view	"I thought it made me understand better by cropping and enlarging the picture. So I can see it clearly"
Evaluation	makes judgments about the value, worthwhileness of textual materials, activities, in-text questions, own position or point-of-view	"I thought the topic shown at the top was good. It told me what I was going to learn."
Generating	formulates one's own questions, examples, ideas, or problems; interpolating; going beyond the data	"What does the handle look like? Stimulate by hands! Do we use hands to do that?"
Imaging	creates a mental image of an idea in text in order to gain a fuller understanding	"I thought about the real muscle and how it should look if I cut it"
Linking	associates or brings together two or more ideas, topics, experiences, tasks	"I thought about the frog's leg in the laboratory."
Metacognition	thinks about, reflects on, evaluates or directs own thinking	"I couldn't see the shrink in the first animation. I thought I need to focus more on the next one"
Recall	brings back into working memory an idea, opinion, fact stored in long-term memory	"This picture, I thought I learned it before."
Reflection	general indication of careful consideration or thought over past action and response; tries to establish the reason or causal link between the action and its response	"When this graph was shown, I thought the latent period is narrow. At first, I thought it would be wide and red like the previous one."

Strategy Planning	plans ways of processing or handling content material during study or learning sessions	"When I saw these, I would open the textbook. I did not wait. I would note the additional information in the textbook."

Table 1: Mediating Processes Identified in the Present Study

Note: Descriptions are adapted from Marland, et al. [14] and Henderson, et al. [8]; examples are from the current study.

The frequencies for each type of mediating process were tallied (Table 2). The data in Table 2 indicate the frequency of the 18 identified mediating processes. The data shows the different frequency of mediating processes between three pairs and the variation in the frequency of occurrence of mediating processes. These ranged from

Categories of classification	*Mediating Process (i.e., thinking skills)*	*Frequency (1st male pair)*	*Frequency (female pair)*	*Frequency (2nd male pair)*	*Total*	*Percentage (%)*
Content	Generating	3	19	11	33	14.5
	Anticipating/Predicting	1	10	20	31	13.7
	Linking	2	14	11	27	11.9
	Metacognition	11	7	6	24	10.6
	Evaluating	6	7	7	20	8.8
	Strategy Planning	0	6	10	16	7.0
	Recalling	8	3	4	15	6.6
	Affective	3	2	9	14	6.2
	Confirming	0	4	5	9	3.9
	Deliberating	1	2	6	9	3.9
	Diagnosing	6	1	2	9	3.9
	Imaging	0	0	7	7	3.0
	Reflecting	1	6	0	7	3.0
	Comparing	0	3	1	4	1.4
	Applying	1	1	0	2	0.9
	Deducing	1	0	1	2	0.9
	Analyzing	1	0	0	1	0.4
	Categorizing	0	0	1	1	0.4
	Total thoughts	45	85	97	227	100
	Mean number of mediating processes per pair from 3 pairs		76		based on responses	

Table 2: Frequency of Mediating Processes Related to Academic Content.

14.5% for "generation" to 0.4% for "analyzing" and "categorizing". A total of 227 mediating processes were identified from the transcripts. The mean number of reported mediating processes per pair was 76. The first male pair who were interviewed after the first lecture reported 45 mediating processes. The other male and the female pair who were interviewed after the second lecture reported 97 and 85 mediating processes, respectively. Familiarity with content and presentation probably influenced the higher number of thinking processes during the second lecture.

Mediating processes	*This study:* IMM in mass lectures (%)	*Study by Henderson, et al.. (1997):* IMM study (%)	WWW study (%)	Text-base study (%)
Generating	very high (14.5)	high (8.4)	very high (10.1)	Low (3.6)
Anticipating/Predict.	very high (13.7)	high (7.8)	very low (1.4)	high (5.9)
Linking	very high (11.9)	very high (11.4)	very high (11.5)	very high (10.4)
Metacognition	very high (10.6)	very high (19.8)	high (9.4)	very high (12.4)
Evaluating	high (8.8)	very high (18.0)	very high (26.5)	very high (18.6)
Strategy Planning	high (7.0)	very low (1.8)	high (7.7)	very high (16.8)
Recalling	high (6.6)	high (6.6)	very low (1.0)	low (4.1)
Affective	high (6.2)	very high (14.4)	high (9.4)	high (7.8)
Confirming	low (3.9)	Very low (1.8)	low (4.5)	very low (2.8)
Deliberating	low (3.9)	very low (1.8)	very low (2.8)	none (0.0)

Diagnosing	low	(3.9)	none	(0.0)	low	(3.1)	low	(0.26)
Imaging	low	(3.0)	very low	(0.6)	very low	(2.4)	none	(0.0)
Reflecting	low	(3.0)	none	(0.0)	very low	(0.003)	none	(0.0)
Comparing	very low	(1.4)	low	(4.8)	very low	(2.1)	very low	(1.5)
Applying	very low	(0.9)	none	(0.0)	none	(0.0)	none	(0.0)
Deducing	very low	(0.9)	none	(0.0)	very low	(1.4)	none	(0.0)
Analyzing	very low	(0.4)	very low	(2.9)	none	(0.0)	very low	(1.1)
Categorizing	very low	(0.4)	none	(0.0)	very low	(1.0)	very low	(0.005)

Table 3:Comparative students' mediating processes frequency between this study and the study by Henderson, et al. [8]

The data in Table 3 show the variation in the frequency of occurrence of mediating processes in our study and that by Henderson, et al. [8] which reports data from three different studies. In these three studies, the tertiary education students had hands-on control of the IMM software, the WWW courseware, and the text-based materials. (Our research was not aimed at arguing that one type of learning material [the IMM in mass lectures, the hands-on IMM study, the WWW study, or the text-based study] was better educationally. Our intention with the comparison frequency of thinking processes was that, if the quality and quantity of reported thinking skills was comparable with those reported in the other three studies, and if hands-on interactivity did not appear to be a crucial factor, then lecturers would feel a level of confidence in using IMM in mass lecture.)

Based on four level divisions used in the Marland, et al. [14], Putt, et al. [7], and Henderson, et al. [8] studies, the frequency of occurrence is divided into very high, high, low, and very low in order. In all studies, the 3% and 10% cut-off figures were arbitrarily chosen, whereas 5.5% (100/18), the cut-off for the "high" category, was the average percentage frequency across all 18 categories.

In Table 3, the categories of generating, anticipating/predicting, linking, and metacognition have the highest frequency (f>10) in this study. According to the study by Henderson, et al. [8], linking was rated very high in learning with the WWW, IMM, and text-based materials as well. However, while anticipating/predicting rated as very high in this study, it rated as low in the WWW study and high in the IMM and text-based studies. Evaluating was reported often in all four studies. It was rated as high in this study and very high in the other three studies. Interestingly, strategy planning was very low (f<3) in the IMM study, but it rated as high in this study and the WWW study and very high in the text-based study. Recalling rated as high in only the two studies that used IMM. Comparison of the results show that ten mediating processes (confirming, deliberating, diagnosing, imaging, reflecting, comparing, applying, deducing, analyzing, and categorizing) occurred in the low to very low frequencies in all four studies.

4 Discussion

The following discussion focuses on the comparison of mediating processes that were reported by students during their learning sessions. In the computer-assisted mass lectures, the A.D.A.M. IMM software was used as a teaching-learning tool. It played a major role in the lectures. However, the students were not in a position that allowed interaction with the IMM. They were a group of passive-receivers who possibly consumed the content provided by the lecturer via the IMM features. Therefore, the data obtained in our study concerns the reported mediating processes of students who learned with IMM without direct hands-on interaction. The comparison data between our study and that reported by Henderson, et al. [8] reveals factors that influenced students' mediating processes while learning with different mediums. Moreover, it also revealed the differences in the quantity and quality of the reported thinking skills when students had direct hands-on interaction versus receiver interaction.

The top frequency percentages for the four studies are 26.5% (WWW), 19.8% (IMM), 18.6% (text-based), and 14.5% (our study). The data reveal a higher percentage frequency of the most reported thinking skills in the studies where students had hands-on interaction control. If we add the percentages of all mediating processes in the "very high" category for all four studies then the differences are 63.6% (IMM), 58.2% (text-based), 50.7% (our study), and 48.1% (WWW). Nevertheless, even though the students in the hands-on WWW study had the fewest reported mediating processes in the very high frequency range, there was only a small percentage difference (2.6%) between it and our study. In terms of these criteria, the data generally tends to support our hypothesis. The students in the hands-on IMM study obviously reported more mediating processes than those in the IMM computer-assisted mass lectures. However, when the number of mediating

processes per person in all four studies is averaged, the results are 38 per person for our study, 16 per person for the IMM study, 36 per person for the WWW study, and 28 per person for the text-based study. The low hands-on IMM number was affected by having learner groups of more than two students; beside two groups of two students there was one of three and one of four students in the stimulated recall interviews [20]. Nevertheless the highest number was in our study where students did not have hands-on control. Moreover students in our study reported more types (18) of mediating processes during learning. Students in the WWW, IMM, and text-based studies reported 16, 14, and 13 different types of mediating processes respectively. The students in the WWW study did not report applying and analyzing. The students in the IMM study did not report reflecting, applying, deducing, and categorizing. Those in the text-based study did not report deliberating, imaging, reflecting, applying, and deducing (Table 3). Breadth, that is, the number and type of different mediating processes are relevant to engaging meaningfully with the content as is the number per individual. Thus hands-on control does not seem to be the crucial factor here. The following discussion examines these issues concerning our hypothesis by singling out various mediating processes for analysis and reveals that our hypothesis is tenuous.

The top four mediating processes in our study were generating, anticipating/predicting, linking, and metacognition in descending order. "Generating" encompasses one or more of the following: (a) formulation of one's own questions, examples, ideas, opinions, problems, and answers; (b) interpolation by adding new knowledge through the elaboration of existing knowledge within a given framework; and/or (c) extrapolation which adds new knowledge by extending an existing framework and going beyond the data. The reason for the very high percentage for generating is because of the cause-effect relationship between their thoughts and the animation features of A.D.A.M., which led the students to focus on the content [21]. Generating has a very high frequency (14.5 %) in our study, a high frequency (8.4%) in the IMM study, a very high frequency (10.1%) in the WWW study, and a low frequency (3.6%) in the text-based study. Therefore, direct hands-on interaction might have caused the lower frequencies of generating in the hands-on study. Students in the three studies reported by Henderson, et al. [8] might have engaged in the jobs they needed to do to control the IMM and the WWW materials and underline or take verbatim notes from the text materials. Thus resulting in less focus on the content. Students in the computer-assisted mass lectures just followed the lecturer's presentation, which may have allowed them to allocate more time to focus on the content.

"Anticipating/predicting" includes predicting, looking forward to, speculating about, and expecting the likelihood of encountering problems, types of content, and features of the medium. Anticipating/Predicting is the second highest ranked mediating process having a very high frequency in our study. It had a high frequency in the other IMM study. A possible explanation for this finding is that the lecturer was the only person who controlled the A.D.A.M. IMM software, thus the students anticipated and predicted what the lecturer decided to present and what would emerge in the A.D.A.M. presentation. Students in the IMM study had direct interactive hands-on control of the IMM. Therefore, it is possible that they automatically clicked the mouse to move to the next page, clicked for the answer to embedded questions, and clicked to control the animation without allowing time for anticipation or prediction. The very low score (1.4%) for the WWW study appears to be an anomaly. Perhaps the content, particularly the instructional design of the content, did not promote these thinking skills. Or perhaps the students used the hypermedia functions of the WWW and engaged in thoughts such as "I will click on this link" rather than wondered what content ideas would be presented embedded in that link. In our study, students in the computer-assisted lectures had to wait for lecturer interaction. Thus, during waiting, they had more time to anticipate or predict the coming content.

"Linking" had a very high frequency in all four studies. It is defined as the process of associating, or bringing together the mind, two or more ideas, topics, contexts, personal experiences, words, and so forth. From this finding, linking occurred easily when text, picture, graphic, or animation that illustrated the concept prompted recall of an associated item in the student's memory. Therefore, it is not surprising that linking occurred very often in all studies because they contain those elements that influenced students to consider how the information related to their experiences. This also shows that, in comparison with our study, direct hands-on interaction did not influence the linking processes.

Mediating processes classified as "metacognition" are those in which students reported awareness of, reflecting on, evaluating, or directing their own thinking. This definition reflects a widely accepted view of metacognition as referring to students' knowledge about, and control over, their cognitive processes. The findings show that metacognition had the fourth highest frequency of mediating processes in this study. The students were able to engage with the content and thinking about their own thinking as it related to the content, and were less inclined to be sidetracked by the features of IMM, the lecturer, and

student-idiosyncratic factors [21]. Metacognition had very high and high frequencies in the four studies (see Table 3). In three studies the percentage frequencies were similar: our study (10.6%), the WWW study (9.4%), and the text-based study (12.4%). However, there was a significant gap between these and that for the hands-on IMM study (19.8%). A factor that possibly made the gap is that the hands-on IMM study contained embedded questions that forced students to interact in order to receive feedback and to be able to move to the next section. In our study, the A.D.A.M. software also offers the same feature, but the students did not have hands-on control. The text-based study also provided embedded questions, but did not provide feedback and also did not "force " the students to answer those questions. The WWW study did not provide embedded questions. This comparison shows that the different pedagogical instructional design in conjunction with the hands-on control is a crucial factor that influenced metacognition. Nevertheless, it is still significant that students engaged in metacognition, which is a type of thinking that is considered to be one of the highest types of cognitive processes [22].

"Evaluating" is defined as the mental process in which a judgement is made about the value or worth of some aspect of the content of the instructional material. Evaluating had a high frequency (8.8%) in this study. The percentage of reported evaluative thoughts about content is very high in the other three studies (18.0%, 26.5%, and 18.6%). The gap between our study and the other three studies is significant. The students in the other three studies used the learning tools by themselves. Thus, it would seem that hands-on experiences and, hence, control over their own pacing and navigated sequencing with the learning tools produced more evaluative thoughts. In computer-assisted lectures, the students may not have had enough time to evaluate the content as well as generate new ideas, link to their past experiences, or metacognise. Perhaps, the students in our study rationalized that if the lecturer had purposely selected out this particular IMM A.D.A.M. material then it was important. In the hands-on studies, the students had to make the evaluative decision as to what content was worthwhile or relevant to their individual goals.

"Strategy planning" refers to thought processes in which students plan ways of processing or handling instructional material or activities during study or learning sessions. There is a dramatic gap between the frequency percentage for IMM study (1.8%) and the other three: our study (7.0%), the WWW study (7.7%), the text-based study (16.8%). The students in our computer-assisted mass lecture study had to follow the lecturer's presentation. One could therefore assume that the frequency rate would be "very low"; but why then the very low score for the IMM study? There appear to be three explanatory factors. The first factor suggests, as is the case with lectures in general, in our study students planned how to deal with the information and process the content through note-taking, drawing graphs, and deciding whether to annotate the textbook or attempt to draw or describe the animations that they cannot control. The second factor is that the students in the IMM study when interacting with IMM, did not appear to spend time thinking about how they would process the material but instead just followed the linear sequence programmed as the "default" choice [8]. The third factor is that, in comparison with the IMM study, in which assessment was not a factor, the students in the computer-assisted mass lectures, the text-based, and the WWW studies knew that the content was assessable. This might have influenced the students' strategy planning.

"Recalling" is defined as bringing back into working memory ideas, opinions, and facts previously stored in long-term memory. It has a high frequency (6.6%) in both studies that used IMM while it was rated very low (1.0%) in the WWW and low (4.1%) in the text-based studies. The gap between the studies that used IMM and those that did not use IMM is substantial. It is possible that the features of the IMM products, such as animation and enforced embedded questions, encouraged students to recall their previous knowledge and experiences during learning.

It is interesting that confirming, deliberating, diagnosing, imaging, reflecting, comparing, applying, deducing, analyzing, and categorizing were rated as low or very low (see Table 3) in all four studies. The type of interaction (hands-on or receiver), the mediums and their features did not seem to influence these types of mediating processes. This implies that factors that should be considered are the content and whether its instructional design prompted these types of thinking skills.

5 Conclusion

It has been argued that IMM is more useful as a learning tool when used individually or with others rather than in mass lectures where students could be seen as merely passive receivers. Our study shows that hands-on interaction does not appear to be such a crucial variable. Indeed in our study, the quantity, quality and range in type of mediating processes were greater than, or comparable to, the other studies. Therefore, the authors argue that IMM can be used as a cognitive tool in mass lectures to enhance various thinking

shills. This study draws the attention of instructional designers and lecturers to the existence, types, and relative frequencies of mediating processes in which students engage with while learning with computer-assisted mass lectures. They were not passive receivers but active receivers. Our study highlights the need for instructional designers to plan educational materials that will activate desired mediating processes as part of student learning in computer-assisted mass lectures.

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The Application of Scaffolding Theory on the Elemental School Acid –Basic Chemistry Web

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The knowledge of chemistry is base on the realization of fact and experiments, students must try to infer, experiment and realize deeply to achieve the goal of highly efficient learning. Base on the scaffolding theory, we have designed a three- tier client-server web title which is a distributional database formats about the chemistry subject-"Acid and Base chemistry" for elemental school students. We use a lot of multimedia animation and Internet techniques to create a scaffolding environment make students learn it instantly and mutually. It turn out that all the students have excellent improvement learning outcomes. All the experts, the interaction designing experts, the network experts, software designers and primary school teachers gave a positive affirmation about the web title; the teaching content and the interaction design are all get the very positive confirmation. The result of learning effect is very convention; the statistical analysis shows that all learners who entered this web site made a great progress in their knowledge test. Besides, ANOVA statistical analysis shows that this scaffolding chemistry web site made a great help for L type learners. Learners' previous science knowledge has nothing to do with the study effect.

Keywords: **Scaffolding Theory• •Acid-Base Chemistry• •Web Title and Learning Effect**

1 Introduction

Because of the shortage of real experience and the misconception of teaching content, traditional teaching cannot inform the students about the concepts which teachers want to deliver. With the development of the Internet, the form of education is shifted from teacher center to the learner center. The future of science teaching is base on the new nine-year consistent project, it is important to integrate the Internet as a major tool to enforce this project. All of these will help improve the quality in elemental chemistry education for our children.

2 Motive and purpose

In these coming years, internet was the major domain of research academics and government officials. In the 1990s Internet software took giant leaps forward in usability. The biggest change came with the development of the World Wide Web (WWW), a vast tract of the Internet accessible to just about anyone who could point to buttons on a computer screen. It led the Internet's transformation from a text -only environment into a multimedia landscape incorporating pictures, animation, sounds, and even video.

The teaching by the Internet exceeds the traditional passive one-way learning, but stresses on interaction. Taking the advantage of instant pass by the Internet, you can browse through all kinds of fascinating information sources and discover worlds of knowledge. We create a web page about the chemical

experiments- the acid and base in nature environment. By the global of networks, we can easily transform the information by character, animation and video. The different learning effect which associated with different learning style students, different ages, different sex and different previous knowledge of science may cause the different learning out come.

3 Theory background

The scaffolding theory brought up by a Russian psychologist (L. S. Vygotsky). He sustains students with the scaffolding techniques through out his teaching process. In the beginning of the scaffolding, it would be a process from other-regulation develops to social negotiation. In teaching, the teacher will design a temporary supporting constructions thought out the whole lecture, which help the learner to develop his learning ability. It is called scaffolding. There are two important subjects within the scaffolding theory. There are communication and cognition, the function of social cognition is to make the learners improve his abilities in solution and self-examination, and students certainly be promoted by the active learning styles.

Scaffolding instruction means that the teacher can help the learner make the most of their potential. Under scaffolding instruction, student will join the learning activity positively instead of remaining passive. Thus, an individual would have his own cognition framework.

There would be six important principles about the instruction.

1.In the real teaching activity, the teacher is the scaffolding maker for the learner.
2.The supporting degree is dependent on the standard of the learners; there would be a modification.
3.The more the ability of the learner increases, the less the support decreases.
4.The support is in proportion to the standard of the activity.
5.The suppor will be modified gradually and at any time. Then it would keep on.
6.Make the learner independent.

In the learning effect, many scholars announce their research results. They would analyzed what kind of the learner is and then decide to create the appropriate on-line instruction web page. Different learning-styled students in CAI(Computer-assisted instruction) would have different learning effects in various feedback.

The feedback is composed of the following four parts:
No feedback. (2) Knowledge of results feedback. (3) Informative feedback. (4) Informative feedback in personal language.

According to the research results by the scholars Dori and Yohim(1990), students in proper sequence may have highly-efficient learning effects. On the contrary, learning by leaping ways was low efficient learning effect. The former is called L type, and the latter is called W type. It means that different learning style may cause various learning effects to students.

The learning ways of students are classified into Super-L, L, W and Super-W type. There are large parts of high school students with L type in particular. The second position is W type. The L type (straight-line) means students follow the learning materials and never change the route. The W type means students don't follow the learning materials and change the route all the time. The Super-W type means that students may play out the entire learning process. It has a strong relation between the learning style and the logical thinking talent.

4 The Research Method

System Installation

The research is base on a web title course, it is a Three-Tier Client-Server sets. Most browsers accepted this kind of device. Server can share responsibility for the management to the request of client. It can transform the information from the database by the request of the client, then the client will process the information it got from the server.

To achieve harmony with education, the government has computerized all elemental schools, but the

schools have not been equipped with highly-performance computer. Microsoft bring up an idea of thin client. A computer with modem and browser can use this system. To have a better web title designed, we got the type called 3-Tier (Figure 1). It bases on the platform of Windows NT 4.0 Server SP6. We created the Web Server with Microsoft Internet Information Server 4.0. As a result of dealing with the users' get-in information, we use the MS-SQL 7.0 Server system as a platform for database.

In the process of making the web site, we use a computer with Pentium III 450 processor, which is associated with Front page 2000 to design all the required homepages. And we use the common draft tools (Adobe Photoshop and Macromedia Flash) to deal with pictures and make them more interactive. Finally, we use the SPSS statistics system to analyze the results of learning effect.

The part of system interface, we use ASP(Active Sever Page) to design the interface, and take the advantage of Visual C^{++} to create a stable and efficient web page in the core part .

5 The Research Object

Our research is aimed at the students in Grade Six of elemental school. The design for course content

We take a lot of real household materials, which is concern about acid and base as teaching examples. Such as the lemon• Clorox and vinegar. The nature of soap water is slippery. If you wet your clothes carelessly with sulfuric acid• hydrochloric acid or sodium hydroxide, the clothes would be damaged. And they will scorch the skin. There would be the calculation of the PH. The definition of acid and base is on the produced amount of H^+ and OH^-.

The vinegar is composed of five percent of acetic acid. The molecular formula of acetic acid is written as CH_3COOH. The one hundred percent of acetic acid is called icy acetic acid. The reason why a lemon has acidity is that it is composed of lemon acid.

In the laboratory, the ammonia NH_3 is a base. It is because it produces a lot of OH^- in water. The ammonium ion is acid. It is composed of H^+. At the normal temperature, the HCl is gaseous state. It is a acid. The carbonic acid H_2CO_3, Sulfuric acid H_2SO_4, boric acid is all acids. There are common base such as sodium hydroxide NaOH and calcium hydroxide $Ca(OH)_2$. Sodium bicarbonate $NaHCO_3$ is a base; it has a common name called baking soda. People with much hydrochloric acid in gastric juice may take some medicine composed of magnesium hydroxide to neutralize.

The experts and scholars suggest that we should create a interactive web page of scaffolding theory should base on the acid-base knowledge map which is created at beginning of the course. The another major frame is an on-line discussion section. Initially we would have some general questions about acid & base, which the students have to find out their own solutions. If their answer is correct, then they can enter another subject, otherwise they have to keep on finding the answers. In the process of learning, students may have an efficient learning freedom by the active video program we provide with in the web page.

The content of the web
1.Question-learning function induce students to learn.2.Question of situation in our daily life.3.A simple operation interface.4.To stress on vision and hearing.5.Guided learning then learning control.

There are twelve units in the teaching material, which is a scaffolding design.
1.Litmus paper. 2.The nature of liquid.3.The definition of alkaline-liquid operation.4.The definition of acidic-liquid operation.5.The definition of neutral-liquid operation.6.The reaction between alkaline and acidic liquid.7.The neutralization of acid and alkali.8.The application of neutralization of acid and alkali.9.The nature of acid and alkali.10.The nature of sodium hydroxide.11.The advanced concept of acid.12.The advanced concept of alkali.

Most of elemental school students cannot understand the nature of acid and base. So we classify the course into two parts, which may happen in real life and in the textbook. We ask the student to register as they entering the studying web page. And let them brow though the entire house, which have five areas (kitchen, bathroom, living room, backyard and bedroom), all fill of the brand name items. The computer will record the pass way of learner, which then will be analysis to learning style (W-type or L-type). If the learner follow every step of the computer, they will have 10 points, which is classify as L-type, if the learner did not

follow the step which computer direct, they will deduct 2 point for each time, the points lower than 3, it is classify as W-type. The acid-base lecture is designed base on scaffolding theory. The system would determine when to removes the scaffolding setup or not by the amount of the correct analysis of computer generated data and suggestion by the experts and the scholars. After a serious study, this system is set up to remove the scaffolding structure when students scored seventy percent of designed questions. Before the system removes the scaffolding structure, the on-line instructor is standing by the side to help them solve some difficult problems. It's so-called on line ICQ.

For example, if students ask what the hydrochloric acid is by the on line ICQ. The instructor will pub out and tell the student that it's a kind of corrosive solution, which is used to clean your bathroom

The hydrochloric acid also exists in our stomach; it helps us in the digest. You can clean the lavatories in the schools or in our home with it, too. And all of these questions and answers will be put into Acess database as a Q&A databank for future use.

If the scaffolding has been removed, a discussion section will appear on the screen. Students can ask any question or play the teacher part to answer questions. We can save lots of the teaching resource in the way.

All the pretest and posttest questions are substrate from ACS (American Chemical Society) test bank, which is careful designed and tested for, determine chemistry knowledge of students.

6 Result and Discussion.

From January 10 to March 10 we have selected 221 students to analyze. And the result of analysis is as follow (table 1):

Table 1. The analytic table about the learning style

Category	Amount	Average	Standard varies
Boy	118	5.65	1.13
Girl	103	5.81	2.08
Whole	221	5.72	1.57

Research Sample
There are 221 students enter our web site for learning acid and base concepts, base on their data collected, we picked up forty learners (twenty are L-type, twenty are W-type) as our study samples. L-type (Boys >7.78, Girls>7.89) and W-type (Boys < 3.52, Girls<2.73)

Evaluate the Web Site
We invited five elemental school science teachers, five teaching scholars, five software designers, and ten elemental school students to evaluate the web site. The average results are in table 2.

Table 2. Statistic of evaluation result

Item	Software designers	Teaching scholars	Elemental teachers	Elemental students
Homepage design	4.50(90%)	4.50(90%)	3.75(75%)	4.50(90%)
Teaching material	3.75(75%)	4.25(85%)	4.75(90%)	4.10(83%)
Interface	4.30(86%)	3.90(78%)	3.60(85%)	4.70(94%)
Whole style	4.25(85%)	4.25(85%)	4.50(90%)	4.50(95%)

In the aspect of homepage design, elemental schoolteachers gave us lower points (3.75). They thought that instructional contents should be more intensive, and the relation knowledge should increase to enrich our web site. The software designers thought that the homepage should be more vivid than previous to stress the topics.

In the aspect of teaching material, some students complain that contents are not obvious, and we should introduce topics clearly.

In the aspect of interface, the teaching scholars and software designers thought that the operation should be familiar with users. In the meanwhile, they generally praised us in animation, and encouraged us used more.

At whole aspect, they all thought that web base learning indeed archiving the instruction targets.

Learning Effect

After tested, all eighty students had been improved in their acid & base knowledge. The overall improved score average is 18.15. L-type learners average improved 23.35, and W-type learners average improved 12.95 (table 3). It is obvious that our web site have much help in learning acid-base chemistry.

Table 3. The statistics of achievement test

L-type	Pretest	Posttest	Improved	W-type	Pretest	Posttest	Improved
Average	55.80	79.15	23.35	Average	51.75	64.70	12.95

We used the SPSS statistics software running data to analysis the deviation. The P value of learning style relation to score of pretest is 0.063, which is greater than 0.05, indicated that the learning style has no relationship to the pretest score. (table 4)

Table 4. Deviation analysis of different learning style relate to pretest score

Deviation source	Degree of free	Average square root	F	P
Learning style	1	529.256	3.499	0.063
Inaccuracy	158	151.258		
Total	159			

The P value of learning style relation to the score of posttest was 0.015, which was smaller than 0.05. It indicate that posttest score was relation to learning style, which means that L-type learning style improved remarkable. (table 5)

Table 5. Deviation analysis of different learning style relate to posttest score

Deviation source	Degree of free	Average square root	F	P
Learning style	1	1829.256	5.993	0.015
Inaccuracy	158	305.240		
Total	159			

7 Conclusion

Instruction by Internet is the better way in teaching chemistry at present day. According to our research, we have three conclusions:

1. After using the web site, the learners all had improved their test score remarkably. It shows that it is a better learning process for students to study acid-base chemistry in the elemental school.
2. The P value of learning style relation to posttest score was 0.015, which was smaller than 0.05. It shows that L-type learner had positive progressed in using scaffolding web site.
3. After the experts evaluated the web title, this acid-base chemistry web indeed bringing on-line instruction into full play. This web site's design style could be a very good example for the future science web sites.

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The Discussion on the Dynamic Knowledge Generationand the Learning Potential Ability

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After we discussed with teachers to understand their instructional politics, we integrate the teachers' instructional politics, the process of knowledge generation, memorizing to construct the concept graph. Furthermore, we used the dynamic web pages to track the learner's learning and used the tracking data to reconstruct the learner how to construct his knowledge to understand the learner's thinking logic. In this paper we proposed the dynamic knowledge generation model and learning ability potential model. These were according to link the concepts to generate the knowledge. As following above idea we integrated the constructing materials and the dynamic knowledge generation to consist the expert system. The system would analyze his learning data to rebuild he how to build his knowledge, to understand his learning ability and he already built the whole knowledge or not. Rely on these results the system could supply the suitable materials to him for study. And the learning cycle would continue until the learner completely constructs the new knowledge into his ground knowledge. Finally, we could from proto type system to collect the experimental data and rebuilt the learner's learning steps, then followed the expert system to understand his learning ability potential. The system could supply a suitable material to him and help him to cross over the learning obstacle. These results also proofed that our model could really understand the learner's thinking logic and learning potential.

Keywords: **dynamic knowledge generation, learning potential ability, concept graph, expert system**

1 dynamic knowledge construct process of learners

A meaningful learning must accord with three main conditions: Accepting the learning material, having the knowledge of dealing with learning material, and firing this knowledge at the learning time, (Mayer, 1975,1984). Accordingly, learning behavior has originality, creation and activity. It's easy to make learners to find the meaning of learning. If we want learners to have meaningful learning, we must do: "if you want to teach active knowledge for learners, you have to understand how to get the knowledge first. It's the same as you want to teach learners to think, you have to understand how learners think first." Therefore, if want to know the learner how to learn the knowledge, it can use the information process theory to discuss the human how to process his information like Fig.1. we design a structural material like a story, attaching pictures, and animations that attract learners. At the last section we give an additional problem among the units, which give learners integrating the prior knowledge. Then, the blind spot in every learner is obtained by using the model of a learning barrier analysis. The reason of inspiring learning barrier is obtained by using learners' browse web pages order and frequency. (Note: 3D learning barrier analysis) Meanwhile, learners will dynamically update their constructional knowledge network by learning number, browsing process, and test frequency. (Note: all of attributions of cognition nodes are dynamical.) Because learners are not static learning, we developed a dynamical model as Fig.1..

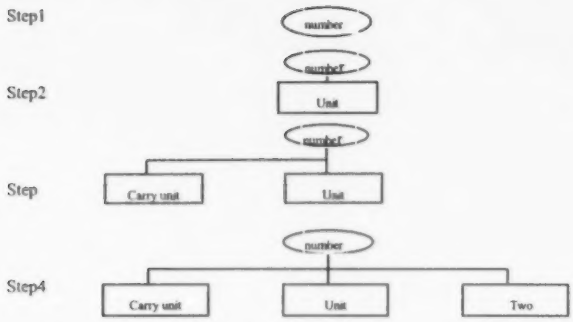

Fig.1 dynamic knowledge construct process of learners

2 the dynamical knowledge generation and learning ability analysis

In our model **(the model of dynamical knowledge generation and learning ability analysis)**, using the teachers teaching experience, the system partition a judge learners' ability to achieve learning and the label of understanding course. And the Table1 is appropriate inference rule, what are the schools' teachers to classify the learners' learning ability.

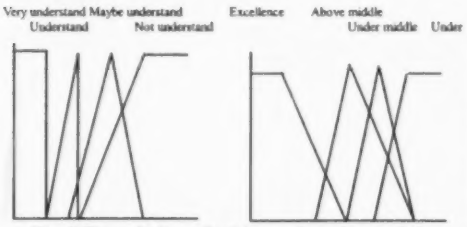

Fig.2 The relation of achieve a learning and the label of understanding course

Table 1. Inferring rule

TIMES / RESULT	UNDER	UNDER MIDDLE	ABOVE MIDDLE	EXCELLENCE
Cannot Understand	-2	-1	-1	0
Maybe Understand	-1	-1	0	+1
Understand	-1	0	+1	+2
Very Understand	0	+1	+1	+2

After the student had to go to the chapter's test. The testing results would according the learning obstacle analysis model to find his incompletely building knowledge and compared with the expert system to understand his learning ability. Finally, the system searched the suitable materials for him to study. The graph of learning cycle is shown in Fig. 3.

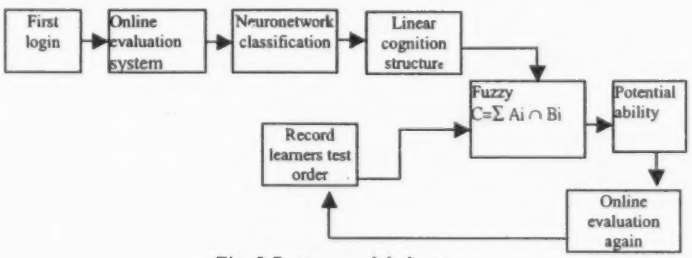

Fig. 3 System model chart

3 Conclusion

Although teacher can control his class ambiance and teaching trends, but he has many different individual

learners in the classroom. If teacher cannot understand the learners how to learn and how to integrate their knowledge on his teaching, the teaching does not only let learner have a stuff learning, but also increase his teaching load. Therefore, in our paper we proposed "dynamical knowledge-generation model and learning ability analysis", to integrate the conceptual knowledge generation into structuring material and connect with the dynamical estimating expert's system. This system can collect what material learner had learned and the result of online testing was transmitted to the system. These real data used our analyzing model to decide his learning ability and supplied a suitable material to him for study. Thus, we believe our system do not only can help the teacher to understand learner how to build his new knowledge, but also can reduce the learner's learning barrier.

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The Externalization Support System of Self-explanation for Learning Problem-Solving Process

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When a learner dose various tasks in the computer, the interaction of the learning support system is so a transition which happens inside the learner. At that time, educational effects such as knowledge structuring occurs due to externalization of representation. We developed the prototype system in so that externalization of self-explanation of the problem-solving process was supported. A learner externalizes the self-explanation "How do I solve the exercise?". At this time, she/he explains using not only words but also diagrams, in order to exploit the effect of diagrams. Self-monitoring happens with self-explanation, and the acquisition of a problem solving strategy on is learned. In this paper, we construct a model of "externalization on the computer," and we consider the occurrence of cognitive load. Learning is a kind of load, therefore any reduction of the load (as opposed to its extinction) is of assistance. We propose the presentation of an operation list as a method of load reduction. The memory dependent evaluation becomes more coherent by such a list. In other words, the cognition perspective improves. In this paper, it is shown in the prototype system how externalization is accomplished.

Keywords: **Self-explanation, Reflection, Externalization, HCI**

1 Introduction

Recently, the contents of interaction have been reconsidered in the context of the learning support system[1]. So far, a computer playing a teacher's role is aimed at the transfer of domain knowledge expressed by the system. The computer asks a learner several diagnostic questions. The computer is central to such interaction. The perspective "For whom is this interaction?" is absent. In this paper, we propose an learnig environment (externalization support system) that promotes the understanding of problem solving resulting from the externalization in the computer. The learner works independently on the computer with the interaction we propose, then the learner rewrites his internal state. Learning occurs at that time.

Recently, attention has focused on "externalization " and "meta-cognition." For example, a vague idea is sometimes clarified by writing text. Externalization promotes the arrangement of knowledge and learning. On the other hand, meta-cognition is a psychic activity of higher order, involving self-monitoring (reflection), and is concerned with deep level learning such as the acquisition of strategies, the transfer of knowledge.

We paid attention to the self-explanation of the problem-solving process, and we have researched that support[2][3]. At present, a learning support system that externalizes self-description of the problem-solving process has been utilized as an experiment. Exercises in statistical scales of geography were used. A learner expresses how she/he solved a problem. Geography though is considered mere memorization, the learner can acquire an understanding

of the problem-solving process by self-description. An example of this type of exercise is shown in figure 1.

We propose the usage of figure 1 as a method of externalization. We are constructing the environment where a learner can do self-explanation by writing memoranda. In this system a learner draws on the character and diagram of the explanation of the problem-solving process. Furthermore, the examination process of externalization is supported from the cognition perspective. The activities scrutinized are internal (understanding the behavioral reason of the learner) and are supported by the presentation of the operation history. This supports the self-monitoring that is crucial to meta-cognition

Idea support system, idea sketch, etc. are proposed in the HCI researches. However, we think learning involves a kind of load, and our purpose is to recommend support by control of the load, rather than by elimination of the load. The consideration of support by reduction of the load is a different point.

In chapter two, we describe the educational effect of externalization. We propose a support method of externalization targeting self-explanation of the problem-solving process in chapter three. The summary of our system is shown in chapter four. We present a summary in the final chapter.

2 The outline of externalization

2.1 The educational effect of externalization

Many researchers point to the educational effect of externalization[5]-[6]. The effect of diagram use in externalization has been acknowledged as well. The learner can acquire the educational effect if self-description is externalized by use of diagrams[7]-[8].

Externalization is the expression of internal psychic activities (images). We mention clarification of knowledge, structuring, etc. as a general effect. Moreover, internalization occurs by repeated externalization, and internal processing proceeds smoothly.

Self-description involves special explanation of a point[9]. Externalization is unique as well. Self-monitoring is enhanced by a learner's repeated externalization of the self-explanation.

2.2 Externalization model on the computer

We construct a model of externalization in this section; our objective is not to clarify the mechanism of externalization. In a sense, the model is to employ educational effect. Various models of externalization are available; we have elected to choose a model of externalization in the computer.

Externalization is considered to consist of several functional modules. The module described here is the functional unit that is comparatively independent.

The model of externalization and the state of repetition of each module are shown in figure 2. We classify modules of externalization into four ways.

(1) Image generation
(2) Expression form generation
(3) Operation sequence generation
(4) Examination (evaluation)

Module (1) is the creative impulse that forms an internal image. Externalization consists not only of the creative impulse of expression but also of the underlying representation. Though module (1) is a heterogeneous activity, it is a part of externalization. Creativity is a very complex psychic activity, and is beyond the scope of this paper.

Module (2) is the expression of vague internal images. Expression is based on the rule

Question: What are items(1),(2),(3)?

Item	Ranking	1	2	3	4
(1)	Exporting country Amount of export	U.S.A 9,637	Australia 5,300	Poland 2,800	U.S.S.R. 2,000
	Importing country Amount of import	Japan 7,909	France 2,295	Italy 1,905	Canada 1,567
(2)	Exporting country Amount of export	Cuba 675	France 300	Australia 255	Brazil 253
	Importing country Amount of import	U.S.S.R. 672	U.S.A. 270	China 222	Japan 180
(3)	Exporting country Amount of export	Japan 1,612	West Germany 1,458	France 675	Belgium* 460
	Importing country Amount of import	U.S.A. 1,802	England 490	West Germany 483	Italy 460

(1)and(2)unit is 10,000 tons. (3)unit is 10,000,000 dollars. * Includes Luxembourg.
(1):1982, (2):1983, (3)1980

Fig. 1 Example of geographical exercise.

of generation. As a case in point, form of presentation (rule) that has been configured freely and formalization that has already been completed, may be employed. For example, in the case of pictures, expression is free, and a person who draws a picture decides the form of presentation. On the other hand, when we illustrate a phenomenon with a formula, formalization is predetermined, and we must obey mathematical rules. As for externalization of writing memoranda, existing formalization and independent formalization are being used together. We can think of module (2) as consisting of the following three usage forms.

(a) Existing formalization
(b) Independent formalization
(c) Existing formalization + Independent formalization

The burden of usage of the existing formalization is that a learner must understands formalization. However, when a learner acquires existing forms, internalization progresses, and the representation in module (1) becomes simplified. For example, when a learner is skilled in the use of the Japanese abacus, she/he becomes capable of mental arithmetic using a mental image of the abacus. The effect of the Venn diagram in the understanding of the set theory is similar.

When externalization is done on the computer, the process of module (3) is remarkable. The rate of this part increases when the expression is done indirectly using the computer. Expression can't be generated if the computer lacks the appropriate software. Thus, a learner plans an operation sequence to configure expression, and she/he will move the mouse based on that plan.

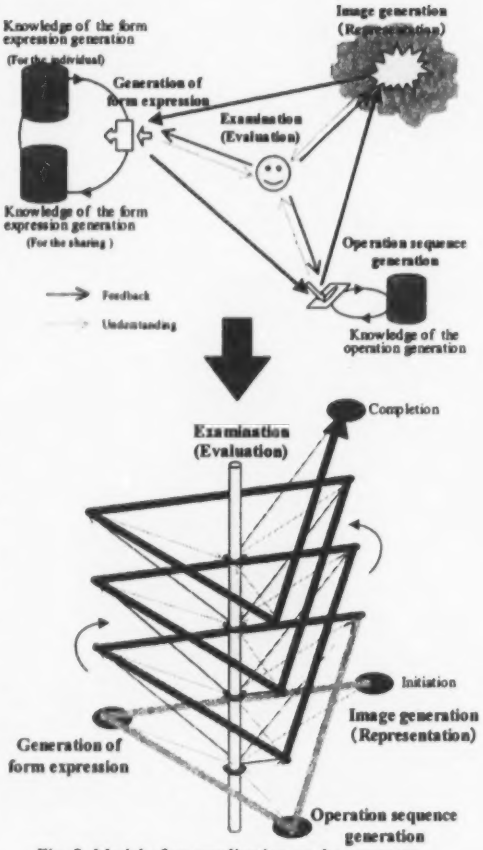

Fig. 2 Model of externalization on the computer.

Module (4) is different from the other modules. Examination is the evaluation of each process from module (1) to (3) with feedback. In other words, examination is a meta-level activity when compared with the other processes.

Modules (1) to (3) become a cycle. The processes from (1) to (3) are evaluated by process (4), which provides feedback. This cycle is repeated until a learner judges by examination. That the activity has been completed

3 Externalization support of self-explanation

3.1 The support of externalization by load reduction

The general support method of externalization is considered in this section. First, we remove the cognitive load intuitively for externalization support. However, the purpose of learning is to put load on the learner. Even if a computer estimates the intention of the learner (even if an explanation is formed automatically,) learning does not progress. Hence, removal of the load does not support learning.

The real nature of the load lies in the multiple combinations of the loads. The load is classified by cause and category, it is necessary to separate the load that aids learning from the load that does not. We aim to reduce the load. In other words, consideration of the relevant control of the load is necessary. Arrangement and classification of each load is necessary for its support.

3.3 Drawing method of the problem-solving process

Support of the expression form generation process serves to prepare for the effective expression method. We show

(by way of drawing) the problem-solving process following. Problem-solving is a process, and it has a certain structure. Diagram usage is effective to express structured information. Graph expression is a relevant method like Tweedier's indication as an informational expression that has a flowing structure[18]. For example, though various methods are proposed, a flow chart is still used for the expression of a program structure.

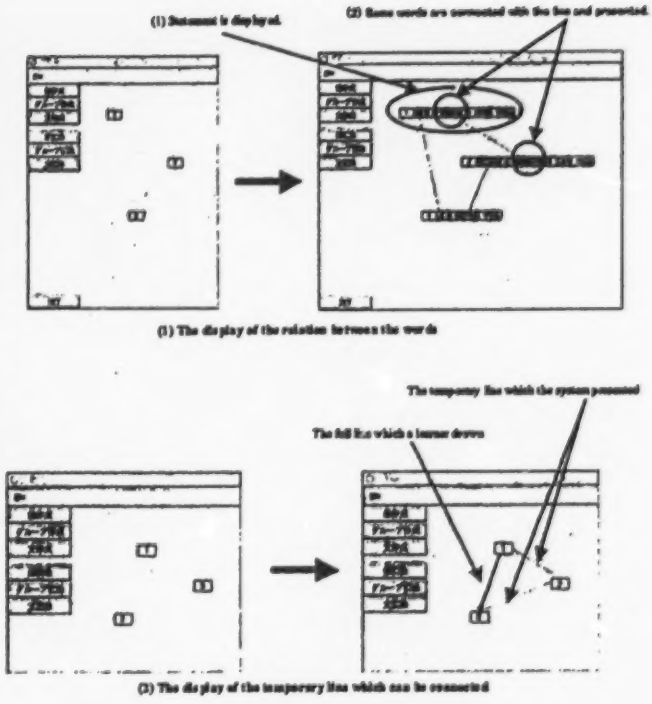

Fig. 3 Model of operation support.

We use a style that combines the use of words and figures. We propose the arrow diagram that expressed structure between statements was symbolically used with the text of the items together. The externalization task with our learning environment consists of two tasks: text creation and graph drawing. Expression is constructed in the following procedures:

(1) The Entering of a simple sentence
+
(2) Placement (migration)
(3) Connection
(4) Grouping
(5) Attribute addition to the object

First, a learner constructs the explanation of the character form. The explanation of the solution reflects the problem-solving process of the exercise. We exclude compound sentences and complex sentences, and use only simple sentences. Each simple sentence during expresses each state of the problem-solving process. A learner is conscious of the order, and notices that problem-solving proceeds by the items. The order of the explanation copes with the process of the problem-solving.

Next, each simple sentence is connected with an arrow line to form a "node". A learner is specifically conscious of the structure by drawing these lines. As for the structural expression of the explanation, each statement is associated with the arrow line toward the explanation of the expressed goal from the explanation of the initial state. A learner encloses some statement, and gives color attribute as a supplementary activity. The diagram drawn with the arrow line is completed by repeating the above activity.

The part that decides expression is first and the part in which a learner himself can determine expression are both present in the above expression method. Such a method guarantees freedom of expression for the learner, while at the same time accepting ambiguity. Thus a learner can write a memorandum of the meaning of the attribute appended by the learner. For example, the system asks a learner for a reason when a learner changes the color of the line. This function is actualized as a fraction of the support of the look-over.

3.4 The support of the operation sequence generation

We describe the support of the operation sequence generation in this section. The following function is provided because the learning environment should be made convenient.

(1) The simplification of the operation
(2) The intersection of the operation and the phenomenon

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The operations of the learning environment are statement creation, statement delete, line drawing, line erasing, movement, grouping, and the color alteration of the object. It prepares only for easy operations. A phenomenon can be easily imagined from these identifiers. We achieve a single function in our system. An operation and a phenomenon correspond one-to-one, and the understanding of the operation becomes easy.

The learning environment is tailored to notify the learner of deficient explanations and feasibility of the expression by the following operation support. The state of the support is shown in figure 3.

(a) The display of the related word information
(b) The display of drawing line feasibility

A simple sentence is displayed on the learning environment as a symbolic icon. One component is made according to statement, a learner can focus on structure between the statements. On the other hand, a certain word sometimes has significant meaning for structural grasping of the explanation. The learning environment manages word information, and employs it for support.

The indication of related word information This is the method in which the structural understanding of the statement is accelerated. When the same word in is used several statements, the learning environment shows them. When the same word is shown repeatedly, the system is made conspicuous. The system displays a statement next to the statement icon, and gives color to that word. The same word in different statements is connected by a line.

The indication of connection feasibility This is the method in which drawing between the statements is supported. The system presents the link that can be connected in the statement nodes as a temporary line. The system estimates the statement that relate to other statements in the placement step (which the statement icon on the workspace finished). The feasibility a line drawn is high in the statement which satisfies the following conditions:

(A) The statement operated just before
(B) The statement that encompasses the same word

The system presents a temporary line to the learner according to the stage at which placement was finished. All candidates are displayed when some lines are presumed. When a learner chooses a temporary line, the system re-establishes that temporary line as a permanent line. Because drawing lines is a possible option, the work of drawing is reduced for the learner.

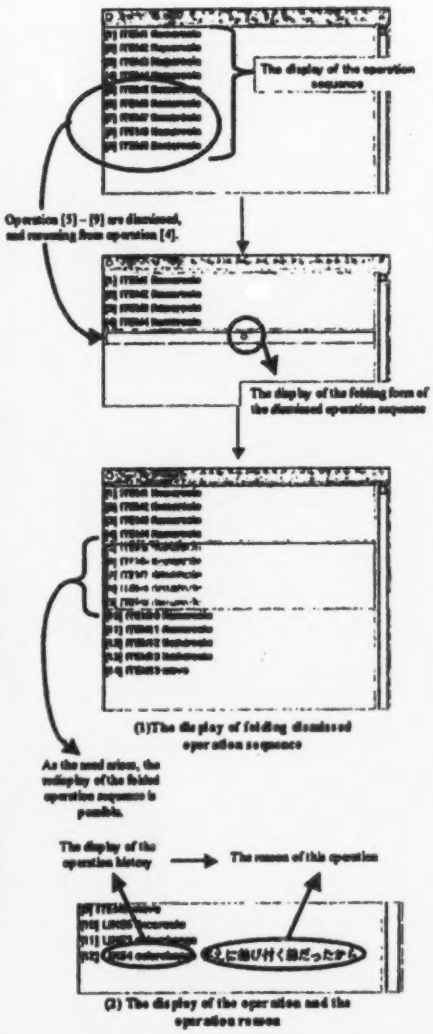
The display of the operation sequence
Operation [5] – [9] are dismissed, and returning from operation [4].
The display of the folding form of the dismissed operation sequence
(1)The display of folding dismissed operation sequence
As the need arises, the redisplay of the folded operation sequence is possible.
The display of the operation history
The reason of this operation
(2) The display of the operation and the operation reason

Fig. 4 Representation of the operation history list.

3.5 The support of the examination by cognitive perspective

We aim at the realization of the farsightedness of the cognitive perspective with the support of examination. Externalization is done so that a learner may learn about himself. We aren't aiming at deputy by the system. The approach of automating conception and drawing isn't embraced. Support toward examination of evaluating one's act is necessary. Therefore, we propose a method that assists the self-monitoring by the learner. The system uses the following two methods, as shown in figure 4.

(1) The display of the operation history
(2) The collection and display of the operation reason

Reflection on the personal task must depend on the current aspect of the activity subject and on memory. However, subject activity does not express variations in the middle of the task. Moreover, memory is often a temporal

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effect, and often can't be extracted when necessary. Therefore the system preserves task history, and history and task process are reproduced to the learner. The system makes linear operation sequences and a learner can do an operation again from the arbitrary juncture of the operation sequence that is presented. In that case, a recent operation sequence occurs from the point that an operation was done again, and a previous operation sequence is dismissed.

However, when a learner reflects on an error, dismissed operational sequences encompass significant information. Because reflection support is critical, the system preserves all operation sequences. When a recent operation sequence occurs, the previous operation sequence is hidden temporarily from the learner. Then, if a learner requires, the previous operation sequence can be displayed. Cognitive perspective in the examination process improves due to the presentation of the operation history.

The display of the operation history provides an opportunity to look back at the operation. Furthermore, we not only present operation history but also present the reason of the operation. The system requires comment input at every operation. The set list of the operation and the reason are stored in the system. It is understood that comment is useful in order to reconsider program source. Ambiguity is present in expression, and the degree of freedom of expression is guaranteed. A learner himself sometimes forgets the intention of the figure on one side. A memorandum of the operation is useful in such a case as well. The presentation (collection) of the memorandum of the operation is not the active intervention of the system.

4 Self-explanation externalization support system

4.1 The configuration of the self-explanation externalization supporting system

Our system before this paper externalized a self-explanation only in character[3][4]. However, figures and text are mixed in the natural externalization. Drawing activity is separated from text creation activity in self-explanation, and it is unnatural to draw after text is written. Therefore our system was designed to enter text and to draw simultaneously.
We implemented three functions in the system.

(1) Explanation management
(2) Explanation structural management (visualization management)
(3) Operational history management

Module (1) manages information on the explanation sentence. This module is shared the entry of the explanation sentence and the display of the explanation sentence. A learner enters a simple sentence. The morphological analysis of each simple sentence is done by "Cyasen" developed with NAIST. Information on the word is extracted. By this processing, information on the noun and verb in a simple sentence is extracted. The system preserves the information with a simple sentence.

The order of the statement input can't be employed as an order of the explanation sentence. When a learner completes a drawing, the system decides the order of the explanation sentence based on the following information:

(a) Related to the arrow
(b) Grouping
(c) Related to the place
(d) Input order

First, the system gives priority to arrow line information. The beginning point and end point of the arrow shows a context. Next, simple sentences are grouped to the same level. The system fundamentally introduces the order of the input as the order of the explanation. When there is no grouping or arrows in the explanation figure, the system decides the order of the explanation sentence based on the co-ordinate information of the icon on the "canvas "screen. If there is a top-to-bottom relationship among icons, this relationship becomes the context. The order of input is used except in the case above. After the system shows the order, the alteration of the order by the learner is possible.

Module (2) manages the drawing task and the information acquired from this task. A learner enters a simple sentence, and next drawing becomes possible. Module (2) manages the whole drawing task on the "canvas", and it displays support information.

Module (3) presents the task history (operational history) of the learner. A learner sees this operation history, and adds various modifications to the externalized figure.

Various methods of presentation of the operation history are proposed. We think the list form is easy to understand. Various methods of Undo (Redo) are proposed as well[11]. We consider an operation to be a series of persistent sequences. We introduce the interface in which an operation can be done from an arbitrary part of the operation history list and the previous sequence folded under the recent sequence. The current sequence is important for the learner, so a dismissed sequence is rendered temporarily invisible. Hidden operation history can unfold the folded part if necessary (the icon indicates it has been folded.), but a learner only confirms a folded operation sequence, and a dismissed sequence can't be redone midway in the process.

4.2 Outlook of the system

We show how self-explanation is externalized on the system in this section.Six windows are displayed in the system that was manufactured. The screen configuration of the system is shown in figure 5.

(1) Canvas window (Operation button is encompassed.)
(2) Simple sentence input window
(3) Explanation sentence display window
(4) History panel
(5) Operation memorandum input window
(6) History display window

A learner does a drawing task on the canvas window (1), and then the drawing consequence is displayed. The learner starts an explanation through this window, and the explanation is written and modified. Various operation buttons are configured. This window performs the role of the console panel of the whole system.

The simple sentence input window (2) is a one-line editor for a learner to input a simple sentence. This window is invoked by the sentence-creation button on the canvas window, and closes when the input is finished.

The explanation sentence display window (3) displays an entered simple sentence with the items. Each sentence is displayed on this window by an entered order. When a learner estimates that externalization has been terminated (the stage in which the "completion" button is pushed), the order is evaluated, and the line of the explanation sentence is replaced. However, a learner can alter the line of the explanation sentence by using the mouse to "drag & drop".

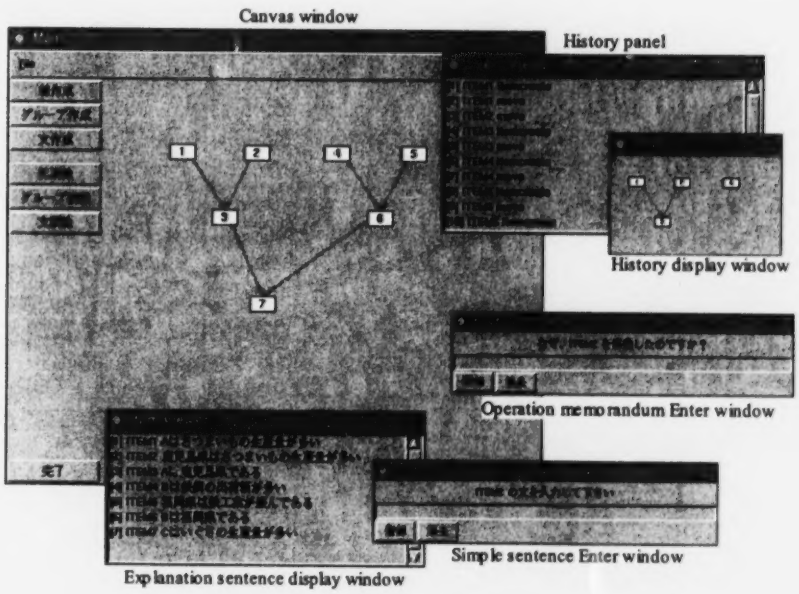

Fig. 5 Screen shot of the prototype system.

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The history panel (4), the operation memorandum input window (5) and the history display window (6) are related mutually. The operation history of the learner and memoranda are displayed in the history panel. Though the memorandum input window is displayed at every operation, a learner doesn't necessarily need to enter memoranda. Entered comments are displayed in the history panel with the associated operation. When a learner chooses an operation from the operation history, the history display window displays the screen image when that operation is done. It is important to simultaneously present the screen image to support cognitive perspective. Moreover, if a learner chooses an operation from the operation history, she/he can redo the operation from there.

5 Conclusions

In this paper, we described a learning system in which externalization of self-explanation of the problem-solution process was supported. Recent attention is founded in the educational effect of externalization; however, the mechanism of externalization isn't clear, and the recommendation of the usage method isn't sufficient, either.

Therefore, we surveyed externalization first, and described the educational effect. Next, we considered the support method of externalization, and proposed the support method of externalization of self-explanation. The first is the method of externalization of self-explanation that employs expression by words and diagrams, such as memoranda. The other method is that of collecting the operation history and presenting it to the learner from the viewpoint in which the cognitive perspective is important for the examination process of externalization. Furthermore, we attempted a system that could leave operation reason when the operation history was collected. Self-monitoring becomes smooth by presenting operation and reason. Finally, an overview of our trial production system was shown. The state in which a learner externalized in that system was shown.

In the future, we will improve the system, targeting each operation to reduce user load, and we will evaluate the system.

Acknowledgment

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THE GOOD, THE BAD, THE UGLY
OR
INTERACTIVE LEARNING ENVIRONMENTS

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Qualitative research methods of interview, observation, and document collection were used to analyze a three-hour (48 contact hours) distance education course. The research team consisted of a professor who was the instructor, an Associate Professor who taught qualitative research and five doctoral students enrolled in an advanced qualitative research class.

There were a total of eight learners in four sites. The learners consisted of a specialized population of male adults who were instructors at two-year technical colleges taking the class in response to a state mandate which stipulated that no one would be allowed to teach at the newly-created two-year technical colleges without a baccalaureate degree. The instructor was a female professor with about thirty-five years teaching experience and eight years experience with interactive compressed video distance education. Nine visiting guest speakers of varying teaching experience and no experience with interactive compressed video also participated.

Initial analysis indicated that strong teaching skills and classroom management skills were necessary to conduct the course. Far-site independence of movement, talk, and turn taking required special give and take between learners and the professor. Modifications of ordinary class behavior on the part of learners and the professor were noted.

Keywords: **Distance Learning, Classroom Environment, Classroom Management, Connectivity**

1 Introduction

The presenter's interest is not in distance education as a whole, but in the interaction between the qualities of distance education and teaching strategies for the professor and a particular set of learners. One of the research projects the presenter has completed in this arena was qualitative and the presenter was the subject of the research. The learners in the study were two-year technical college teachers, who were working on a bachelor's degree in vocational education. Since qualitative research is time and context bound, it is difficult to make inferences that would apply across time and context to all teachers who deliver instruction through distance education . That is, these distance education classes occurred in a specific context, with specific groups of people, in specific places, in specific situations, and at a specific time within the current guidelines of distance education technology. The significance of the research lies in the notion of transfer [9]. Transfer is the type of inference qualitative research uses instead of the quantitative notion of generalizability. Consequently, it is up to the reader to draw inferences about how the research time and context fits his/her own time and context. This is in direct contrast to quantitative research which makes decisions about the inferences generated by rejecting null hypotheses. Qualitative research is an appropriate research methodology because all distance education is conducted at a specific time with specific people, in a specific place, and under specific circumstances [19]. Distance education is a practice rather than a laboratory setting; therefore, professors need to know more about the practice in a practical context-bound environment.

After eight years of teaching in a distance education classroom, the subject had many questions about what strategies were truly facilitating learning. There was also the question of whether a professor with more than thirty years of teaching experience in a traditional classroom could be successful in a distance education classroom. What were the similarities and differences between the classrooms? What issues would an experienced professor need to become cognizant of if he/she wanted to be a successful distance education teacher?

In qualitative research designs, the role of the researcher should be clear. Researcher roles range from participant observer to detached observer [15]. In this particular investigation, the researchers (excluding the subject) did maintain a role usually associated with detached observers. Their position was off camera in the back of the originating site. Although the researchers did travel to each site to observe and interview learners, the majority of observations were conducted in the originating classroom.

The primary observer, interviewer, and document collector was an Associate Professor who taught an advanced qualitative research seminar; the other five researchers were doctoral students in an advanced qualitative research seminar. The observations were overt in nature. The Associate Professor who was teaching the qualitative research seminar appeared on camera at the subject's invitation to introduce the research and inform the participants that their identities would be protected. Informed consent forms were sent to and signed by each person who participated in this research project, which included not only the professor and learners, but also guest lecturers and technicians.

Methods of assuring trustworthiness of the data were prolonged engagement, persistent engagement, triangulation, member checks, and peer debriefing [13]. Prolonged engagement means establishing a long enough contact with the object of research for the purpose of locating patterns in the data. Prolonged engagement was achieved to reveal patterns in the data as opposed to a collection of anecdotes. The entire distance education class was observed by one or more observers. Standardized open-ended interviews were conducted throughout the entire class; for example, three interviews were conducted with professor/subject and one interview was conducted with each class member. Documents were collected throughout the course at the same time the professor/subject distributed them to learners. Persistent engagement was achieved by constant analysis of the data as it were collected to establish patterns in the data and to exclude discrepant information which was anecdotal in nature. For example, sometimes learners who were present in the classroom with the professor might move closer to the professor to gain her attention. This was anomalous because the behavior was controlled for and was eliminated. Therefore, it was not a behavior that was a pattern throughout the course. Although possibly significant, it was an anecdote rather than a pattern. Data triangulation and researcher triangulation were also utilized to enhance the trustworthiness of the data. Data triangulation included observation of each class session, interviews with the professor, each learner, guest lecturers, and technicians. The instruction was documented through 48 hours of observation and approximately 30 hours of interviews with the professor/subject, learners, guest speakers, and technicians. Researcher triangulation was achieved through step-wise replication, which was a technique used during data collection. Step-wise replication is the use of multiple observers for the same observations. This technique was used in order to reduce the biases that might be present in any one single observer. Member checks were conducted with the professor because she was the focus of the research. A member check is a review by the research informant of interviews, observations, or documents. In the case of this particular research, the professor thoroughly reviewed interviews conducted with her in her role as a co-researcher. Peer debriefing was conducted by the six observers and interviewers at seven different meetings during the course.

2 Setting

The primary setting of the class was a state of the art distance education classroom at the University of Arkansas, College of Education and Health Professions. The classroom was designed for distance education and featured appropriate technical characteristics. The professor usually was seated at the front of the classroom behind a large desk approximately eight feet by four feet (8' x 4'). She also could stand behind or in front of the desk or sit at any table with on-site learners. The professor had three different cameras: one was mounted on a monitor (resting on an approximately 4' cabinet toward the center back of the classroom) which follows the movement of the professor; the second camera was attached to a monitor (resting on the same kind of cabinet as the monitors in the rear) to the

professor's right as she looked at the classroom and pointed toward the class; and the third camera had the appearance of an overhead projector and conveyed printed materials much in the way an overhead projector would except through the compressed video system (ELMO). There was also a computer and a SmartBoard available. The professor used a wireless lavalier microphone. There were microphones shared between every two learners, which when turned on activated the learner camera. There were four monitors resting on the aforementioned cabinets; one 52 inch monitor which showed the professor the far-site learners and one 36 inch monitor which allowed the professor to view the near-site and two 52 inch monitors on one side of the professor for the learners to see near and far-site camera outputs. There was sound absorbing material on the wall, carpet on the floor, and neutral colored wall coverings around the room. Behind the instructor the wall was covered with a camera-blue paint for possible use of special effects. Seating for learners consisted of six-foot tables placed in rows to one side of the room with comfortable office chairs, as opposed to standard learner desks and chairs. Far-site classrooms had varying arrangements and color schemes.

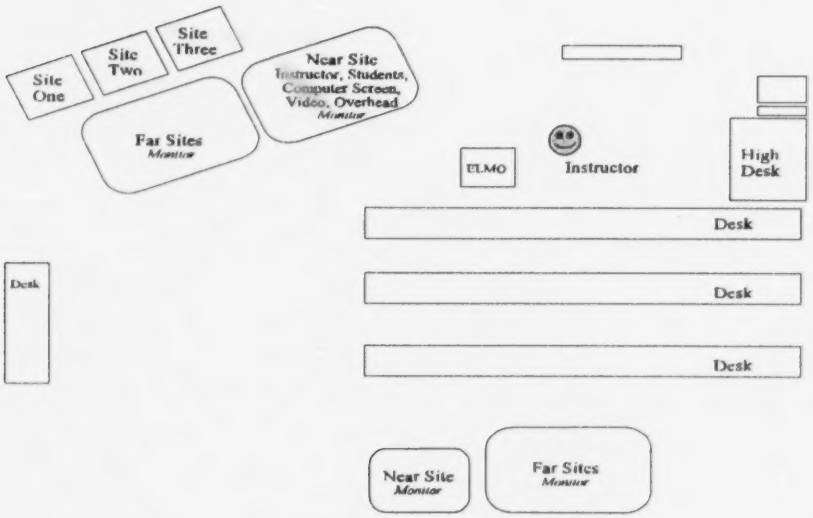

Figure 1. Distance Education Classroom

3 How the Technology Functions

There are four or five sites that combine to form the single distance education classroom. The professor was confined most of the time to the front desk in order to manipulate the controls for cameras and visuals. In her direct view were4 two large monitors, one side contained the camera feed for the near site while the other monitor showed the far sites. Only one far site could be viewed at a time. Selection of far-site location was voice activated; that is, if someone at a far site was speaking, the system automatically selected that site for viewing. Consequently, the professor could not select far-site locations for viewing at her discretion. Communication with learners was conducted through on-line compressed video imagery, world wide web, facsimile machine, electronic mail, standard U.S. mail service, and telephone. Of these options actual class time was centered around compressed video imagery. Guest speakers had been

invited to convey information to learners during the courses. Each of the guests was provided the opportunity to view the professor as she modeled utilization of the system before the guest presented. It has been interesting to note that most guests expressed discomfort with the system, but subsequently seemed to work well with the system. Guests were never required to manipulate the system; the professor performed that function for them. Technical difficulties have been noted as part of the functioning of the system. Technical difficulties included feedback, problems with playback of videos, and interruption of compressed video signal due to weather conditions. All sites had some local technical assistance, though it was minimal.

4 Activities

The professor used a variety of interactive activities, such as lecture and questioning, self assessment, in-class individual and group work, guest lectures, learner demonstrations, individual and group reports, and cross-site dialogue — teacher to learner and learner to learner. A typical class period featured an introduction by the professor, which included personal exchanges with learners. Other attributes of a typical class session were professor lectures with visuals, which consisted of projection of the content on the ELMO or on the monitor from the computer such as a slide show presentation, continual questioning and clarifying, and short video tapes. The professor might introduce a guest speaker. The class session would then proceed to engaging the learner in activities, such as group work, learner teaching demonstrations, and presentation of learner reports. The professor also traveled to each far-site two or three times during the semester, depending on the need.

5 INTERACTION OF DISTANCE EDUCATION CHARACTERISTICS WITH TEACHING STRATEGIES

This section is really the heart of the story. The following table lists the differences and similarities between traditional classroom instruction and distance education instruction for this particular professor and a particular group of learners [10]. Although the table describes both similarities and differences, the emphasis today will be on what teaching behaviors the professor had to modify because of distance education. Modifications include those associated with environment, presentation of knowledge base, classroom management, nonverbal communication, feeling of connectivity among learners and professor, methods of communication, and technical problems.

Table 1

Similarities and Differences Between Traditional and Distance Education Instruction

Similarities	Differences
• **Environment conducive to the teaching-learning process** o Become just as frustrated when cannot talk immediately o Learners want to be part of class o Diffuse anger or frustration ASAP o Face to face o Can establish rapport, but takes more effort o Make each learner feel welcome, at home, and glad they came o Nurturing positive attitude	• **Environment conducive to the teaching-learning process** o Difficult to read nonverbal cues o Situations may require explanations because all learners cannot see all that is happening in each classroom o Teacher and learners have narrow perception of the classroom itself, because all there is is the screen o Exhaustion of teacher and learners due to length of class period and number of previous hours in class o Rapport is more difficult because learners must be brought along at each meeting as if it is a new class, as you cannot see faces and cannot tell where they are, so you have to assume no one is with you o Informality is more difficult to maintain when teacher is confined to one spot o May be more stressful to professor than traditional classroom
• **Presentation of knowledge base** o Extensive preplanning o Transparencies for focus o Relevance of material o Setting up a learning activity o Teaching blocks of 15-20 minutes o Refer learners frequently to text	**Presentation of knowledge base** o Size of visual materials o Color of visual materials o Lectures need to be visible o Speak more slowly o Operating equipment without distracting from content
• **Classroom management** o Recreational stress management — joking, getting them ready to engage with me; an organization process o Have to manage learners the same — if they are not on target or if they are going things you do not want done — always a constant o Make assignment, which is introduction for next class	• **Classroom management** o Easier for the teacher to become isolated and self centered and be the fountain of knowledge because it is easier to handle class that way o Length of time it takes for class materials to reach learners and learner work to reach me (if the web and e-mail is not used) o May have to hold something that needs immediate discussion, because it is not in the hands of all learners — makes spontaneity difficulty o Timely feedback difficult o Encourage learners talk more and/or to work in groups if we are experiencing audio problems o Model for guests so they see what happens when camera jumps from site to site o Difficult to do group work across sites because of sound interruption to other learners o Have to make special arrangements for private conversations o Takes more direction for guests, especially to have appropriate visuals ready and class materials to learners ahead of time o Physical proximity cannot be used to control a disruption — all there is is verbal proximity
• **Nonverbal communication**	• **Nonverbal communication** o Observation difficult due to camera focus and lack of camera control in multiple sites o Limited movement unnatural

Similarities	Differences
• **Feeling of connectivity among class members and professor** o Connecting with learners personally through acquaintances or experiences o Be who you are and operate the same o Call each individual by name o Let learners know who you are o Introducing learners; establishing expectations; setting the stage for involvement	• **Feeling of connectivity among class members and professor** o Look regularly at the camera o Treat each site as if it were an individual in a larger class; call each person by name when they speak or when called upon o Learners may feel isolation, especially near-site learners, because camera is usually on teacher; the fewer the learners, the more the isolation o Professor had to make notes on learner needs, because in jumping from screen to screen (classroom to classroom), easy to lose site of needs o Learners usually have trouble speaking — breaking in and speaking up and out
• **Attention to physical appearance** o Clothing, makeup o Enthusiasm, humor o Voice tone/pitch o Pauses o Gestures	• **Attention to physical appearance**
	• **Methods of communication and or interaction** o Facsimile machine o Electronic mail o U. S. Mail o Telephone o World wide web
	• **Technical problems** o Manipulation of equipment distracts o Feedback in sound system o No on-site technician for problems o Exhausting for professor to have one screen moving them from site to site; split or multiple screen desirable o Limited professor movement due to microphone, camera and controls; otherwise, technician must be in room o Disconcerting to jump from classroom to classroom o Camera focus too distant for reading nonverbal communication o Having to look at another camera to see where professor is in relation to monitor may make teacher look distracted when checking it o Determining if system will be back up when it goes down and what to tell learners about staying or going home

Environmentally, the primary difference is a two-dimensional far-site communication that is limited to the focal length of the lens. This limitation excludes detail, relevant off-camera occurrences, and access to a great deal of nonverbal communication. For example, on numerous occasions learners requested that the professor move her camera closer to her face so they could see her facial expressions. This greatly restricted the professor's movement and eliminated hand gestures and body motion that she normally used to provide emphasis. Such a restrictive environment often causes stress to professors and learners and makes rapport problematic.

Presentation of the knowledge base required more time to deliver because lectures needed to become more visible and the professor needed to speak more slowly. On one occasion the professor was discussing an overhead transparency point by point and a learner remarked, "Please slow down; I can't hear you that well through the system." The combination of lack of screen resolution that is characteristic of a television image and the poor sound quality required more time to deliver instruction. One of the reasons that sound and picture quality can be poor is the need to reduce the band width in order to match the distributor's system which does not always match the originating signal. In addition, a distance education professor's attention must be devoted to operating equipment as well as to delivering content. Frequently it takes longer to deliver instruction via two-way compressed video; therefore, it may decrease the scope of the course.

The majority of the differences noted between traditional and distance education instruction appeared in the classroom management category. Normally physical proximity can be used to control classroom disruptions. That is not available to the distance educator. It is extremely difficult to take a learner aside for private conversations. The professor did this primarily through e-mail and telephone communications. Although it is beneficial to plan materials and instructional sequences ahead of time, the lack of physical proximity to learners and the inability to introduce new materials rapidly reduces spontaneity of instruction. For example, a far-site learner might request information about a regulation concerning affirmative action, which involved completion of certain forms. The professor would have to get the forms to the learner before he/she could discuss the specifics of the question. This is one example among many about how physical distance from learners reduces opportunities for the teachable moment. Physical isolation from learners means that organization and direction of the class can easily become centered on the professor which could cause the professor to utilize more controlling teaching strategies. It should be mentioned that guest speakers needed to be encouraged to prepare further in advance for their presentations and also had to be introduced to the technology. This sometimes produces a much more formal presentation than was appropriate for the particular teaching situation. The principle investigator's notes in the verification study included references to the stiffness of the guests as they presented. A member check with the professor revealed that the same guests were much more relaxed during traditional classroom presentations.

Nonverbal communication suffered significantly because the camera sees so little and with poor clarity. For example, with three or four remote sites and only one site visible on the monitor at a time and possibly only one learner on camera, the professor could not gain nonverbal feedback from the class as a whole. Even when as many as three learners were on camera at a single time, the camera was so distant that few nonverbal cues, except those involving the whole body, could be observed; for example, facial expression or hand gestures were not readily conveyed.

The feeling of connectivity among class members and the professor is different in the distance education setting. The system used in the College of Education and Health Professions is voice activated which causes learners problems with taking turns, because when they speak the picture jumps to their location; therefore, it is difficult for cross-site discussions to take place. The professor had to use special strategies to establish a classroom community from the four or five sites. The professor approached the task of creating one classroom by recognizing the personality of each site and then the personality of each learner at that site. These personalities were a product of the individuals and the technologies they had at their disposal. For example, there was one group that expressed a reluctance to use the ELMO at their location, while other learner sites would not speak in order to prevent the camera showing their location.

Methods of communication controlled methods of interaction. In a traditional classroom the professor can take a learner aside for a personal conversation while others are working on individual or group projects. However, in the distance education classroom what one learner hears, all learners hear. Of the means of communication utilized in the class, only e-mail or the telephone offered the possibility of a personal conversation.

Technical problems sometimes eliminated class or disrupted class. For example, line feedback made verbal communication very difficult on numerous occasions. On one occasion a storm at a distributing site caused the elimination of one class period. Other technical problems included picture quality, problems with showing videos in real time, and limits on my movements. In spite of these differences between the traditional classroom and the distance education classroom, it is still possible for a class to be conducted on a regular basis and with favorable results.

6 Conclusions

This discussion of similarities and differences between traditional and distance education instruction has centered on the differences rather than the similarities. The researchers have heard many speakers state that there is no difference in teaching in a traditional or distance classroom. The professor knows from eight years of experience there is a difference and is trying to understand the nuances about distance education. The differences cited were classroom environment, presentation of the knowledge base, classroom management, nonverbal communication, feeling of connectivity among learners and professor, methods of communication, and technical problems.

The cumulative effect of these differences resulted in a reduction of what is being called social abrasion. Social abrasion means being present which implies physical proximity and the social abrasion that such physical presence produces [14]. For this discussion social abrasion has been separated into the following categories: physical distance, emotional distance, simultaneous two-way verbal and visual access, private communication, and local knowledge.

Physical distance is an important part of social abrasion. In western civilization each person maintains approximately a three-foot distance between their body and the body of other people. This distance is either reduced or expanded based on interactions with others [6]. The expansion and contraction of this physical distance is an example of the abrasion between one person and another. Abrasion means contact and social exchange. This abrasion is done socially through verbal and nonverbal communications. If people are separated physically as they are in distance education, this sort of social abrasion is extremely reduced or nonexistent because there is no three-foot parameter to expand or contract. Physical distance also decreases interpretation of nonverbal communication. In a long camera shot facial gestures are lost, hand gestures become smaller, and a coherent sequence of body movements become unavailable to the viewer.

Emotional distance is increased through the possibility of physical presence. For example, the threat of being physically harmed or the pleasure of being physically touched are eliminated through distance education. Emotional identification with someone who is simply an image on screen may be more difficult [1]. This is one of the reasons why the professor visited the far sites. Trust in part may also be a function of physical distance. According to some researchers [5], credibility is a product of appearance and personal identification and is problematic when mediated. Authenticity can be achieved by the handling of real objects and the sharing of those objects in a common space [8]. Personal narratives delivered by professors or guest speakers may be less realistic when conveyed through a medium normally associated with fantasy [1]. Simultaneous two-way verbal and visual access are standard in a traditional classroom environment but are not guaranteed in distance education especially when visual access is limited to one site at a time in a multi-site communication. Social abrasion also means the possibility of one on one private oral and written conversations. This is extremely problematic with distance education because what one person says is heard by all. Also important to social abrasion is the honoring of local knowledge [7]. It is possible that knowledge like bread is best make locally [17]. For example, the classroom experience and interpretation of the meaning of course content can vary from site to site [2]. Meanings can vary from site to site because different sites may represent clusters of people with similar experiences that are unique to their areas. For example, professors sometimes have a site which will consist of persons who work at the same industry and may be at different levels of authority within the organization. It is probable that their experiences and knowledge and their meanings differed from other sites [4]. The inability to bring everyone together in one location to produce a common discussion seems impaired by distance education. The combination of these elements — physical distance, emotional distance, simultaneous two-way verbal and visual access, and private communication — and the maintenance of distinct knowledge bases (local knowledge) throughout the course may mean that distance instruction produces different outcomes than traditional classroom instruction. It is these outcomes upon which the research focused. It is the findings of that research the professor draws upon as she develops courses and teaches via two-way compressed video.

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The Impact of Learning Style on Group Cooperative Learning

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Cooperative learning has been around a long time and there are many researches and practical uses of cooperative learning. This study is to examine students' attitude toward group cooperative learning processing with individual's underlying learning style. We use Gregorc's Learning Style Delineator to group students heterogeneously and use some factors of Social Cognitive Theory to measure group processing. The findings indicate students with concrete/sequential learning style are tentative to be lack of self-efficacy on setting their goals and therefore teachers should take more care of them while doing group cooperative learning activities.

Keywords: **Cooperative Learning, Learning Style, Social Cognitive Theory**

1 Introduction

Cooperative learning means students working together to accomplish shared learning goals and to maximize their own and their group members' achievements (Johnson & Johnson, 1994). Cooperative learning is widely adopted by the educators since 1980s. Students perceive that they can reach their learning goals if and only if the other students in the learning group also reach their goals (Deutsch, 1962; Johnson & Johnson, 1989). A vast amount of evidence from research in related areas suggest that in cooperative learning situations there is a positive interdependence among students' goal attainments.

Although cooperative learning makes students to learn much better than competitive learning and individual learning in groups, there are still many potential barriers to make group effective, such as lack of sufficient heterogeneity, lack of groupthink, free riding, and lack of teamwork skills (Johnson & Johnson, 1994; Johnson & Johnson, 1996). The basic elements of making cooperative group with high performances are positive interdependence, face-to-face promotive interaction, individual and group accountability, appropriate use of social skills, and group processing (Johnson & Johnson, 1996). Thus how students interacting with other group members and groups processing are the critical successful factors in cooperative learning. By considering individuals' underlying learning style, the purpose of the study is to examine students' attitude toward group cooperative learning processing.

In the Bostrom, et al. (1988) framework individual difference variables define the cognitive aspects of human activities. Thinking process is at the heart of all such activities including learning. Learning style is one of the cognitive traits, which are static aspects of information processing affecting a broad range of variables (Bostrom, et al., 1990). To aim for sufficient heterogeneous grouping, this study chooses learning style as the main variable concerning the impacts of group cooperative learning.

To examine individual's interaction during group processing, this study use Social Cognitive Theory (SCT) (Bandura, 1986), a widely accepted and empirically validated model of individual behavior (Compeau & Higgins, 1995), to reflect the cognitive aspects of students' learning activities, such as self-efficacy. SCT emphasizes the triadic reciprocal causation of behavior, cognitive and some personal factors and environmental events (see Figure 1). Three aspects of Social Cognitive Theory are especially relevant to the organizational field (Bandura, 1988; Wood & Bandura, 1989): the development of people's cognitive, social, and behavioral competencies through mastery modeling, the cultivation of people's beliefs in their capabilities so that they will use their talents effectively, and the enhancement of people's motivation

through goal systems.

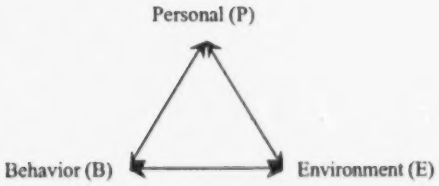

Figure 1. Schematization of the relations among behavior (B), cognitive and other personal factors (P), and the external environment (E) (Bandura, 1986; Wood & Bandura, 1989)

According to Social Cognitive Theory, many researches showed that past performance, self-efficacy and goal setting are the main personal factors effecting performance. Although there are many other factors in the range of the theory, we just discuss the impact of learning style on self-efficacy and goal setting in this study.

There are some other factors exerting considerable influence over group performance. For example, group cohesiveness and group norms. Cohesiveness means all forces (both positive and negative) that cause individuals to maintain their membership in specific groups. Group cohesion means the mutual attraction among group members and the resulting desire to remain in the group. Norms means the rules or expectations that specify appropriate behavior in the group and the standards by which group members regulate their actions (Johnson & Johnson, 1996). Group performance is affected by the combination of cohesiveness and group norms rather than cohesiveness alone (Langfred, 1998). In this study, we also investigate the impact of learning style in group cohesiveness and norms.

2 Method

2.1 Subjects

The subjects were 43 girl's senior high school students who participated in the AJET (Advanced Joint English Teaching, *http://ajet.nsysu.edu.tw*) project, which was supported by MOECC (Ministry of Education Computer Center, APNG-Education (Asia Pacific Networking Group) and I*EARN in Taiwan (*http://www.iearn.edu.tw*). Therefore there are no differences in sex and age among them. The subjects were run in groups and Table 1 is their proportion of learning style. We'll explain the types of learning styles later.

Table 1. Learning Style Frequencies

Learning Style	AR	CR	AS	CS	Total
Students Numbers	15	17	7	4	43

Every group was assigned a project to make English web pages about one topic: Signs or Foods in 6 weeks. Every week they had tow hours on learning how to make homepages by Microsoft FrontPage 98 and doing their group's project as exercises in the computer classroom. Before the experiment, they had learned some basic skills for building their own personal webs.

2.2 Procedure

During the 6 weeks, there were three 2-week sections in the experiment. In the first week, the subjects were asked to fill out the self-efficacy, goal setting and group cohesiveness questionnaires. The same questionnaires were conducted in every section. And in the second week, they were asked to fill out the group norm and satisfaction questionnaires after their performance measurement made by the teachers.

2.3 Measure

According to the procedure, this study assessed learning style and 5 constructs: group norms, group cohesiveness, self-efficacy, goal setting and satisfaction.

2.3.1 Learning Style

In this study, the Gregorc Learning Style Delineator was used to measure the learning style (Gregorc, 1982). Gregorc' s model is one of several models developed to improve understanding of the way students learn and the way teachers teach and is a cognitive model designed to reveal two types of abilities, perception and ordering. Perceptual abilities mean through which information is grasped, translate into two qualities; abstractness and concreteness. Ordering abilities are the ways the learner organize information, either sequentially (linearly) or randomly (non-linearly) (Leuthold, 1999). Thus there are four learning categories: abstract/ random (AR), concrete/random (CR), abstract/sequential (AS) and concrete/ sequential (CS).

2.3.2 Group Norms

Group norms was measured by 5 items on 7-point scales, which indicate the amount of effort put into work, the attitudes toward work load, the willingness to give up free time to work, the feeling of responsibility for work goal attainment, and the feelings of self-worth when work is accomplished well. This measure is developed based on the literature of group work norms (Langfred, 1998). The Cronbach alpha for the group norms measure was .839.

2.3.3 Group Cohesiveness

Group cohesiveness was measured by 6 items on 7-point scales, which defines the feeling of individual group members toward other members and the group. This measure is based on the literature of Langfred (1998). The Cronbach alpha for the group cohesiveness measure is .79.

2.3.4 Self-efficacy

Self-efficacy was measured by 8 items, which asked the respondents to rate their expected ability to accomplish the project with different levels of goal. For example, the respondents were asked whether they could accomplish fifty percent of the project and how much confidence they have. This measure is developed based on an extensive review of the literature of self-efficacy (Compeau & Higgins, 1995). The Cronbach alpha for the self-efficacy measure is .963.

2.3.5 Goal setting

Goal setting was measured by 4 items, which asked the subjects' commitment to their goal of the projects. This measure is developed based on the literature of goals (Locke, 1984). The Cronbach alpha for the goal setting measure was .68.

2.3.6 Satisfaction

Satisfaction was measured by 5 items on 7-point scales, which asked the subjects' satisfaction of the performance of their group project. This measure is developed based on the literature of satisfaction (Dennis, Kinney & Hung, 1999). The Cronbach alpha for the satisfaction measure was .913.

3 Results

Since the Cronbach alpha values of all experiment measures are .891, .8767 and .8646 respectively, this experiment was reliable. An overview of the data is displayed in Table 2, and the results are displayed in Figure 2, 3, 4, 5 and 6.

Table 2. The mean of every measure

Mean	Group Norms	Group Cohesiveness	Self-efficacy	Goal setting	Satisfaction
Section 1	5.16	4.90	529.77	5,66	4,94
Section 2	4.90	4.60	561.16		4,56
Section 3	4.86	3.76	574.42	5,60	5,05

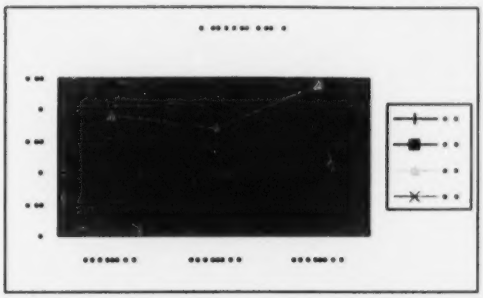

Figure 2. Effects of Learning style on group norms

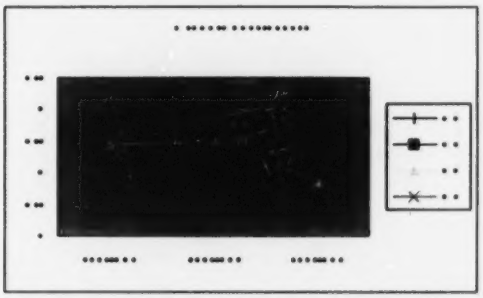

Figure 3. Effects of Learning style on group cohesiveness

The effects of learning style on group norms and group cohesiveness in the three 2-week experiments are not statistically significant, and the results are showed in Figure 2. Because the subjects were grouped since three months ago in the beginning of the semester, the group norms were already statically existed and were identified with group members.

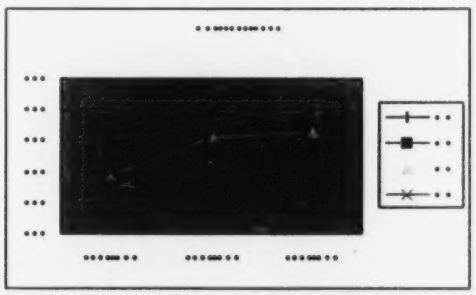

Figure 4. Effects of Learning style on self-efficacy

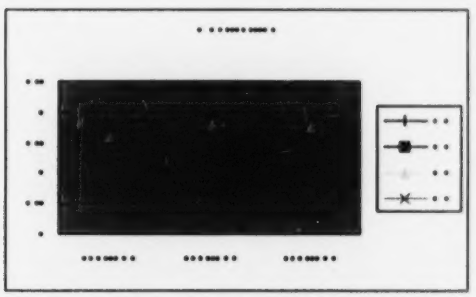

Figure 5. Effects of Learning style on goal setting

The effects of learning style on self-efficacy and goal setting are more significant than group norms and group cohesiveness. The results are showed in Figure 3. Students with concrete/sequential learning style had less self-efficacy during the experiment and were afraid to set their goal higher. Maybe the CS style students feel difficult to make web pages since it is somehow an abstract skill and needs to think randomly.

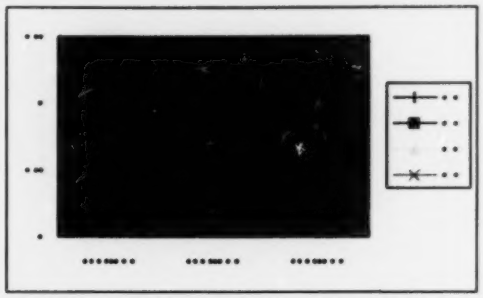

Figure 6. Effects of Learning style on satisfaction

The effects of learning style on satisfaction don't have significant differences, and the result is showed in Figure 4. It showed that all students enjoyed group cooperative learning and were satisfied in this way of learning.

4 Conclusions

In general, all students performed well in the group cooperative learning and felt satisfied with group processing. Although the students with concrete/sequential learning style were few and far between the subjects in this experiment, a quarter of general students would be this kind of learning style. Teachers should give them more encouragement to make them getting more self-efficacy and setting the right goal. Moreover, this study only uses Gregorc Learning Style Delineator to examine students' learning style. There are many other kinds of learning style evaluations, such Kolb's (1976) Learning Style Inventory (KLSI), Canfield's (1988) Learning Styles Inventory, etc. Future researches may use these questionnaires to examine which one is more suitable for cooperative learning.

And about the Social Cognitive Theory, there were many studies showed that the triadic aspects could form some models, which would affect each other in some relationships. Since the sample size is too small, this study doesn't prove the model by statistic methods. This is a limitation of this study. Understanding the effects between group norms, cohesiveness, self-efficacy and their performance will be an interesting research topic.

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The Usability Aspects of an Universal Brokerage and Delivery System for the Pan-European Higher Education

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This paper gives short overview of a recently launched EU project for universal exchange of university course units for the higher education based on a brokerage and delivery system model. The basic components and characteristics of the approache are described. More attention is given to the approach that will be used for assesment of the innovation and for evaluation of the learning and educational achievements.

Keywords: **distance learning, brokerage and delivery system**

1 Introduction

The new technologies are transforming the ways business operate and the ways people work. They are also reshaping the expectations, needs, and opportuniies in education and learning. The customers of the education market are forcing the education to become demand-led, rather than production driven. The current technologies are providing basis for a new just in time, on demand approach the electronic educational products to be offered by virtual or classical universities through special platforms acting as intermediaries between the consumers and the suppliers of educational material. It is clear that the new tecnology alone will not make this new model of more efficient education to happen by itself. Rather, new innovative models of production, brokerage, delivery and presentation are needed that will put together the participants of the education process to collaborate globally and to use the advantages of the powerful technology.

The European project »UNIVERSAL-brokerage and delivery system for exchange of university course units for the Pan European Higher education« [1] is one of the attempts this model to start to work. The project is part of the Vth Framework program of User friendly information society [2] funded by the Commission of European union. The project started in March this year and will last 3 years. The conzortium of the project is large as it encompassess 17 partners from EU[3], among them twelve higher education instituitions from all over Europe, two research organisations, one SME[4] and two telecom service providers. The consortium has also partners from outside Europe as the model developed is expected to have global applications. These are: the Moscow research institut, HEC from Montreal and Nanyang Technological University from Singapore.

The model and the implementation in UNIVERSAL is based on an education brokerage and delivery system being developed to incorporate training by provision of valued-added services to both the customers of the system and the suppliers of the educational material. The major characteristic of the system is offer of different types of learning and delivery of the educational material and its distributive nature. There is no central site for delivery of educational material. Additional characteristic of the model is the system that will be developed for pan-european acreditation of the purchased and performed university course units by the participants belonging to institutions of the European higher education system. At this early stage of the

[1] UNIVERSAL –IST-1999-11747
[2] URL:http://www.ispo.cec.int
[3] EU stands for European Union
[4] SME- Small or Medium Size Enterprise

project is not possible to predict all expected circumstances and consequences that such system may have in the furure development of the educationa nad training. Brokergae approach in provision of distance education must first address a number of technological and educational isues which are part of the UNIVERSAL work program. In depth discussion of the pedagogical paradigms that may take place as well as te number of technological issues of the work program are not possible to be discussed in this article because of space restriction. Here, we concentrate on the basic characteristic of the model; highlithing the implementation scenario and giving more information about the usability aspects of the technology that will be evaluated through monitoring of the educational.

2 The model and the architecture of the system

The model being developed is based on creation of an open, cross-border, educational market environment coupling brokerage and delivery of "live" and "packaged" [5] courses. The proposed framework accommodates and adds value to the various business models and course structures employed in European HEI[6] institutions. It will enable:

- a single faculty wishing to experiment with the simple import of external material to enrich a specific course,
- an existing alliance between institutions to make their exchange more efficient and to enrich it with types of course units not previously exchanged,
- an Open University to extend the range and depth of its courses.

The UNIVERSAL brokerage platform is an interactive hypermedia environment offered to the academics and administrators of European educational institutions to plan and select courses. It de-couple offers and course units provision on the supply side from enquiry, booking and delivery on the demand side. The most important element that enable this de-coupling is the catalogue of offered educational material and the supporting processes, that adequately describes all the properties, educational and technological of the course units. This approach is implemented as brokerage platform and a number of delivery platforms, see Fig.1.

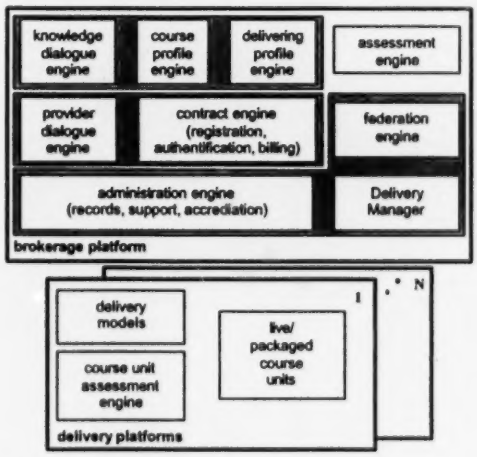

Fig.1 The general architecture

The brokerage platform is further divided in a customer part, a provider part and an administration part. In the customer part, a knowledge dialogue engine is responsible for the dialogue to the demanding institution or to the enquiring student. When interacting with customers, the dialogue engine establishes their background knowledge and guides them in the selection of a course unit. Prospective customers are

[5] Packaged courses are multi-media textbooks and WWW based courses, live courses are CWCS broadcasted courses

[6] HEI stands for Higher Education Institution

presented with choices according to a) pre-requisites and conditions attached to different types of courses (course profile engine), b) the suitability of different Institutions offering courses and c) the different delivery modes available for a particular course (delivery profile engine). Students will be able to make inquiries and express interest in course units that their home institutions have pre-selected and are willing to recognise and give credit. [7]In the provider part a provider dialogue engine is mainly used for feedback from the system back to the content provider. It is also used to handle the offer of content provision to the brokerage system to help academic and administrator users to plan new courses, submit course units, obtain customer records as well as learning progress profiles and assessment results. Demands for course units are sent to the administration engine, which looks for, offered course units fitting into the demand profile. The contract engine sets up the contract between offering and demanding side, thus it is dealing with registration, authentication and billing. In the administration part the system is driven by the administration engine, which is mainly a service database combined with a search engine. The tasks of observing and managing course scheduling and delivery issues, as well as timed interactions between the system and customers to enable the provision of joint courses are the responsibility of the delivery manager. The federation engine is dealing with distribution issues of the engineering implementation, like consistency, caching, forwarding of requests.

For each class of course unit there is an appropriate delivery platform. Variations in delivery platforms are due to the nature of the interactions and differences in media content and formats. The project will implement a limited range of delivery platforms, linked to the brokerage platform, sufficient to show the potential of the model. Each delivery platform contains an inherent delivery model and specific elements dealing with the media content itself.

3 The technology applied

The technology used is ubiquitous, Internet based, offering common, portable solutions and large-scale, shared, cross-border systems. These systems include, but are not restricted to:
Brokerage system is WEB based with Internet links. It is a central point of information, control and administration and logically will be centralized which means that only certain parts will be distributed or redundant for reasons of performance and high availability. The brokerage system will essentially be an E-business system that uses technologies like XML, Java / RMI, CORBA / ODP traders or agent based systems. standard security technology and intrinsic service negotiation for content delivery. Advanced transaction and billing functionality based on AAA[8] security technology, implement sophisticated administration and monitoring interfaces to the delivery systems and the integration of assessment capabilities

Delivery system similarly to the brokerage platform consists of an existing product/technology plus some enhancements ("glue" or "shell" around it), that acts as mediator between the delivery system and the brokerage platform. Defining a unique architecture for this interfacing allows adding additional systems / products by just implementing the appropriate interfaces that plug into the general architecture. A delivery system within the general architecture (see Fig.1) consists of content source, network and content sink. The content source can be a standalone system or part of a broader platform. The same applies to the content sink. The following delivery systems previously tested and used will cover the required functionality: Non-real-time delivery systems: retrieval of non-real-time mono-media and multimedia contents (e.g. browsing through text and hypertext information, download of content files). Real-time A/V systems: Real-time retrieval of multimedia contents (stored and live contents including A/V material like MPEG-2 streams) in synchronous and asynchronous manner (on-demand, live and scheduled broadcast scenarios) using IP technology (unicast, multicast), and broadband technology (ATM, ADSL,). CSCW systems: Videoconferencing and Computer supported co-operative work (CSCW) to enable interactive forms of tele-lectures combining parallel transmission of A/V streams and course material (e.g. slides) with the possibility to interact with the lecturer as well as with other parts of the audience. This family of delivery systems shall also support real-time experiments, simulations and case studies.

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[7] Scheduling of actual course units remains the prerogative of the institutions and booking of places on courses is considered to be an internal function of the institutions

[8] AAA stands for Authentication, Authorization and Access Control

All delivery systems are inter-working with the brokerage platform and content provider systems to synchronise announcement and content delivery, to guarantee controlled user access, and to manage selection, compatibility and resource usage in delivery. All supported delivery modes will be available as profiles of the A/V delivery family. This means that each content provider can easily select the appropriate profile according to the nature of his contents and his network resources. It is important to note that used the A/V delivery technology is not based on the current average bandwidth and quality availability of the ubiquitous Internet. It will offer real high quality of A/V contents as broadband communication over the Internet (with technologies like ADSL) for a relevant number of users is available in Europe as well as the broadband services emerging in the convergence technology market (broadband over Satellite or cable-TV, interactive digital TV services) are expected to boost the widespread usage of broadband A/V information in the global IT environment. CSCW technology applied follows the principle of standards compliance and openness as for example the powerful CSCW tool ISABEL, developed in the RACE and ACTS projects ISABEL and NICE, then the standards-based (e.g. ITU H.323) COTS products (e.g. MS NetMeeting), MBONE multimedia conferencing tools (VIC, VAT, WB) developed within project MECCANO etc.

4 Content provision and description

The general architecture and model envisaged as a point of interaction of "sellers and buyers" on one hand, and of "place of commerce for actual content" requires an intelligent abstract description of the contents. Therefore, meta-data standards for multimedia contents and for educational environments are applied in the catalogue building of course units. The meta data system used is based on the specification of the IEEE LOM 3.8 meta-data scheme[9] with some extensions relevant to the platform developed as for example: attributes that specify the copyright and IPR[10] protection, attributes that describe information about digital signatures, watermarking, attributes that describe the network requirements for provision of appropriate quality of service, attributes relevant to live content and attributes defining the type of the course unit which may be: packaged, live, CSWC or mixed. The content provision and course description is based on a meta-dada system selected from available standard documents or previous projects results (1).

Several projects, that have investigated the management of information retrieval and the utilization of metadata for education and training have already proposed sets of meta-data requirements, like the Instructional Management System (IMS) project in the US (2) or the GESTALT (3) project in Europe. Some of the proposed sets have been evaluated and selected for the use in the UNIVERSAL project.

They are:

- **Learning resource content meta-data:**

Learning resource content meta data that enables cataloguing of contents of arbitrary aggregation level. UNIVERSAL supports the following granularity levels: *Fragment (Course Unit)*, *Lesson*, *Module* and *Course*. Each learning resource submitted by the "seller" is classified according to the aggregation levels and is added to the UNIVERSAL catalogue. UNIVERSAL supports "packaged" learning content, which is asynchronous in nature and synchronous learning content. Synchronous learning content is delivered as live transmissions of lectures, optionally supplemented by synchronous group ware communication technology. The special or unique features of the live content is described by specially developed attributes that are not part of the current existing meta-data standards.

- **Course structure meta-data:**

The UNIVERSAL brokerage platform not enables "buyers" to locate, use and re-use single course units. A functionality of the brokerage platform enables combination of single course units into higher levels of aggregation e.g. for full subject. This allows production of "custom" tailored complete courses. This is reflected in the course structure meta enabled by Course Structure Format (CSF) defined by the AICC and the ADL (1).

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[9] IEEE Learning Objects Metadata document by WG 12 of IEEE Learning Technology Standardization Committee, URL:http://ltsc.ieee.org/wg12/scheme.html

[10] IPR stands for Intellectual Property Rights

- **Contents packaging meta-data:**

Like many other LMS, the UNIVERSAL platform offers the possibility to access packaged course units, which are mainly pre-recorded. Packaged courses enable an interaction with the contents itself, the interaction with the lecturer is usually not offered. UNIVERSAL packaged courses are described according to well-defined rules, specified e.g. in available standards like the IMS CPS (Content Packaging Specification).

- **Descriptive information about assessment procedures:**

Assessment is an important concept in on-line education and learning. Although the UNIVERSAL platform is not designed to assess the student' s advancement and the learning achievement, it will enable consumers or "buyers" to assess the functionality and usability of the platform and the delivery process. The assessment is performed with on line involvement of the students. Student' s responses will be captured using some form of structured mechanism with designed template(s) for such purpose. This is especially required in the cases when questions in the templates involve multiple choice, matched items, text selection, etc. Several structures exits for this purpose already: QML, SATML, and the IMS "Question and Test Interoperability Information Model" (QTI), UNIVERSAL team will decide which of the proposed template will be used for particular part of the platform and the delivery system used.

- **Meta-data for synchronisation:**

The asset management is important if the system is built up from re-usable learning resources e.g. units of lower aggregation level as is the case with UNIVERSAL catalogue. . In such cases the lifecycle management of the unit must be supported e.g. a component is not deleted from the asset management system in cases when the course unit is added to a module or larger course. This property of the system is described within the meta-data for synchronisation.

The UNIVERSAL consortium brings together a selected group of engineering and business schools across Europe who are interested in pooling their academic resources for the purpose of broadening the choice of courses and pedagogical materials offered to students and teachers and to provide opportunities for international collaborative learning. Although a few of its members have already established bi-lateral academic exchange programmes, in the initial phase of the project, partners are collecting course units developed within particular partner or outside in order to build a catalogue for the greatest market potential for the brokerage platform. The catalogue contains in addition to the meta-data information also: brief description of the educational objectives of the academic content for the students to whom courses are offered. In addition to that, brief description of teaching methodology used at each institution, description of the academic calendar for each institution, and description of the academic accreditation process for each institution are also information provided in the catalogue. Currently course units are collected from the following fields: Introduction to Information Systems, Regional Economic Development and Telecommunication, Global Marketing Management, Business Case studies, Metallurgy simulations and experiments, Foreign Languages and Cross-cultural Behaviour, Statistics for Economist, Tele-management.

The UNIVERSAL brokerage platform enables to locate, use and re-use single course units and combine single course units into higher levels of aggregation. This approach makes possible a definition of custom tailored structure for a complete course, which will lead, to a definition of a standard system of granularity for learning resources with the other projects from the IST cluster "Flexible University".

Several institutions already made suggestions for a hierarchy of aggregation levels. The IEEE LTSC and the IMS so far define four levels of granularity: *Fragment*, *Lesson*, *Module* and *Course*. Some other US based systems of aggregation can be found in the bibliography enclosed (8).

A course structure representation defines all of the course elements, the course structure, and all external references necessary to represent a course and its intended behaviour. The ADL together with the AICC, IEEE and IMS have developed the so-called Course Structure Format (CSF) which was the recommended approach for the UNIVERSAL project. The CSF promotes reuse of entire courses and encourages the reuse of course components by exposing all the details of each course element. The CSF is intended to reduce or eliminate dependency of a course on a particular LMS implementation.

The CSF is also intended to represent a wide variety of course structures and content "aggregations".

Content structures can be represented by the CSF that range from very small "chunks" of content – as simple as a few lines of Hypertext Markup Language (HTML) or short media clip – to highly interactive learning content that is tracked by an LMS. The CSF is neutral about the complexity of content, the number of hierarchical levels of a particular course (i.e., "granularity"), and the instructional methodology employed to design a course.

The UNIVERSAL platform incorporates continuous assessment of content and the system itself based on the interactions between the customers using the delivery of course units and the system itself. This information will be used to improve the overall scheme and the content to teachers, administrators and other possible customers.

5 The usability and evaluation

"Evaluation is the activity that throughout the planning and delivery of innovative programs enables those involved to learn and make judgement about the outcomes of the innovation concerned "[11]. The UNIVERSAL project aims also to develop tools to monitor the innovation process of education and learning and to develop best practice guidance.

The assessment of the content and the overall system, components for functional assessment are incorporated in both the brokerage system and in each of the delivery systems. Results from previous projects including the deployment of trans-national multimedia learning schemes[12] have shown that it is vital that all participants involved in the creation of the exchange platform and its educational content have a mutual understanding of the platform' s operations, functions and of the components' interaction. To fulfill this goal it is necessary to give the users the tools enabling an easy the use of the exchange platform such as: an administrator guide, oriented towards the management of the platform, from a technical ("how to use") point of view as well as from a content ("what to do") point of view; a user guide, describing the day-to-day use of the system e.g. to a teacher wishing to use content available through the platform (how to access the catalogue, how to book a live course, etc). In addition, in the case of "live" delivery systems (on-line live courses with CSWC), experience have shown that it is necessary to organise "hands-on" training sessions to free the teacher from the fear of new tools and to strengthen their "moderation" skills when working with a geographically distributed class through a TV-like systems. Classes in the live courses will be mainly cross-border meaning that most participants will not be working in their mother tongue and there will be a mix of cultures present in any one of the classes. As part of the preparation for participation in the main trials a short "Language & Behaviour" courses that will (I) help participants with their colloquial English (since the majority of the courses will be held in English) and (II) help them be aware of differences in cultural behaviour, e.g. questioning style will be provided.

The student/teacher ratio varies greatly among the UNIVERSAL consortium partners. A set of software monitoring tools are being studied to be implemented into the brokerage platform to make it possible for students to continuously assess their personal progress and to choose the academic path best adapted to his or her acquired knowledge and skills; for course unit providers tools will be used to improve the effectiveness of programmes offered to learners and modify content accordingly; tools will be used also to analyze the way learners use the courseware provided; to enable a global assessment of the usability of the platform etc. The monitoring tools as well as the usability evaluation techniques used for assessment of the innovation technology approach are being developed/selected in accordance with the ACTS Usability Evaluation Guidelines[13]. These guidelines define the testing and evaluation methods, experiments design, definitions of interviews, observations, heuristic evaluation and surveys.

The evaluation instruments for courseware evaluation and corresponding measures will include:

- Pre-task/post-task questionnaires
- Task experience questionnaires
- Computer experience questionnaires
- Exams or assessment of performance
- Post course questionnaires

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[11] Stern(1988) in Evaluation of Learning Technology Implementation, by Barry Jackson, URL:http://ltdi.icbl.hw.ac.uk

[12] Project LEVERAGE AC 109 from the IV Framework Program-ACTS

[13] USINACTS – AC224, IV Framework Program -ACTS

- Knowledge quizzes
- Logs - logging times

The approach for educational assessment will follow the practical guidelines developed within the LTDI technology developed within the Learning Technology Dissemination Initiative funded by the Scottish Higher Education Funding Council[14]. As a result of this a set of guidelines identifying best practices for future users of an academic brokerage platform will be produced. Academic partners will have the possibility to review the existing experiences and pool their lessons learned from prior involvement in flexible, distance, and collaborative teaching and learning programmes. This information cover issues such as the choice and format for resources provided to students and teachers, access to tutors or teachers, methodology, independent study and collaborate work, learner motivation, learner monitoring, course accreditation etc.

6 Conclusion

The UNIVERSAL is a project that implements the EU policies regarding the development of the European higher education and the user-friendly information society in particular:

- By improving the quality and diversity of the pan-European HE system
- By promoting the globalisation of the exchange of HE course units
- By enabling partners from economically disadvantaged regions, particularly in Central and Eastern Europe to participate in these developments and helping them to strengthen and enrich their course offerings and the foster the education in general.

Most of the activity within the project will be tightly connected with the usability aspects of the applied methods and technology. Usability evaluation and proposed improvement will be based on the past experiences, guidelines and standards developed within projects that have addressed this issue of modern technology in depth. The consortium expects wide acceptance among the higher-level education institutions in Europe.

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Virtual Inhabited 3D worlds and Internet Based Learning Environments

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This paper addresses some of the central questions currently related to 3-dimensional Inhabited Virtual worlds (3D-IVWs) and their virtual interactions and communication in Internet Based Learning Environments. First, 3D-IVWs-seen as a new and unique form of multimedia-are introduced and the social construction of the 3D-IVW technology is briefly discussed. Second, a selection of the basic concepts and identifiable entities in 3D-IVW s is denned and commented upon. Third, modes of interactivity and (virtual) interactions between users, avatar, bots, etc. in the new Virtual Worlds are briefly presented and typologized. Finally, two Internet based virtual inhabited 3D learning environments -one US-based and one based in Denmark- will be described and analysed.

*The paper was not available by the date of printing.

Web Speaking: A Language Learning System in the Web

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Due to recent technology advances, an increasing number of applications are being ported to the Web at rapid pace. Such applications include Web Phone, Web Fax, Web BBCall, to name a few. Among others, network education has emerged as an important Internet application since it not only avoids the limitation of physical learning locations but also keeps the flexibility of teaching time. In this paper, we develop an interactive language learning system in the Web, called Web Speaking. By using Web Speaking, students are able to learn languages anywhere at any time as long as a Web interface is provided. Web Speaking is in essence a two-tier client-server architecture, and is divided into two components, namely (1) the language learning player at the client-side and (2) the course content provider at the server side. In this system, we put not only the course content but also the corresponding audio files in the server side in order to support a multimedia-teaching environment. The language-learning player runs at the client side and provides a user interface to access the course materials in the server. In addition, Web Speaking is able to improve the language speaking ability of the students with the display of the speech waveform which is generated by using the algorithms isolating the utterances of the speech. Students can capture the difference between the waveforms of their own speaking and the standard one provided by the instructor, and improve their speaking accordingly. By this language learning package, we can automate the procedures of preparing audio course materials, greatly facilitate the language learning by the students, and conduct data mining on student behavior. The teaching quality of language learning can thus be improved.

Keywords: **Distance learning, speech analysis, two-tier client-server architecture, World Wide Web**

1 Introduction

Recently, an increasing number of applications are being ported to the Web at rapid pace, including Web Phone, Web Fax, Web BBCall, and so forth. Among others, network education has emerged as an important Internet application since it not only avoids the limitation of physical learning locations but also keeps the flexibility of teaching time [1,2,3,5,6,7,8]. Traditionally, the students have to be present in the language-learning classrooms and use specific language learning mechanisms to improve their speaking ability. However, the major disadvantage of the traditional language learning is the limitation of time and space. For example, the students may have an English class in the Monday morning at the language-studio classroom and that class could be their sole opportunity to practice their language speaking, since the instructor is only present at that moment. Consequently, the effectiveness of the traditional language-learning systems is limited.

In this paper, we develop an interactive language learning system in the Web, called *Web Speaking*. The Web Speaking system we developed in the Computer and Network Center at National Taiwan University is in essence a two-tier client-server architecture. Through a Web interface, the students are able to not only learn the lessons anywhere at any time but also practice their speaking at leisure pace, thus overcoming the limitation imposed by time and space. In addition, using Web Speaking, students can communicate with the instructors interactively via the mechanism provided, and the teachers can timely edit the course materials

by writing the content of text and recording the audio files in response to the students' requests very easily. These are the very advantages of Web Speaking over some stand-alone commercial language-learning applications which are usually lack of interactive features.

In addition, the other major contribution is to provide the displays of the speech waveforms produced by the teachers and the students to help the students to learn language speaking better. In Web Speaking, we implement the algorithms isolating the utterances of the speech [9,10] to improving the students' speaking ability. Through the display of the speech waveforms, students can perceive the difference of the speech waveforms between their own speaking and the one prepared by the teacher, and improve their speaking accordingly by themselves.

Web Speaking has been distributed to some language learning groups in our campus for experimental use and been well received thus far. It is worth mentioning that Web Speaking system is meant to help the teachers to improve their teaching quality, and should be viewed as an auxiliary tool for teaching. By no means do we assert that Web Speaking is able to completely replace the role of an instructor or in any way to lessen the need for a teacher to personally interact with students. We believe that by exploiting the availability of Internet, Web Speaking is very instrumental to the traditional in-class teaching and will improve the quality of teaching results significantly from both the perspectives of students and instructors.

The paper is organized as follows. Section 2 depicts the whole system architecture. Section 3 presents the implementation and functionality of the Web Speaking. Section 4 concludes this paper.

2 The System Architecture of the Web Speaking

We use a two-tier client-server architecture for the Web Speaking system. The reason of using the two-tier client-server architecture is that it can provide our two key components, i.e., the language-learning interfaces at the client side and the course content provider at the server-side. This architecture can be easily extended to a three-tier one if an additional gateway is required in this application.

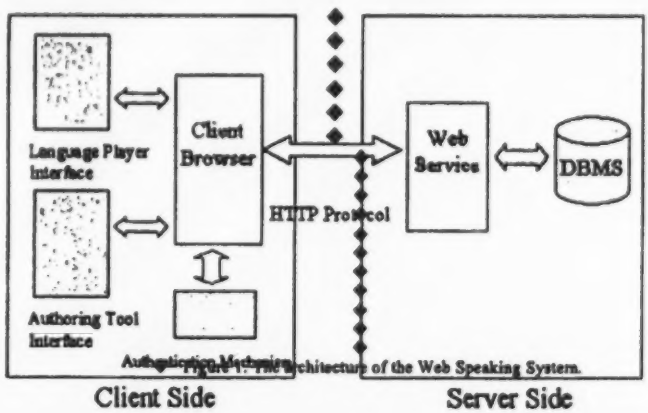

Figure 1. The Architecture of the Web Speaking System.

Based on the two-tier client-server architecture, the Web Speaking System is designed as the Figure 1. At the client side, both the language player interface and the authoring tool interface use the DBMS (Database Manager System) to access the course materials in the server via the HTTP protocol in the Internet/Intranet. The program at the serve side then accepts the requests from the clients and returns the results of the requests to the clients. The DBMS at the server side saves not only the course materials but also the information of the users, including the students and the teachers. Using an authentication mechanism, the player is able to verify the user identification via the Web and to provide different user interfaces for students and teachers, as one form of personalized service. For instance, the students are only allowed to use the language player interface whereas the teachers can use both the language player interface and the authoring tool interface. The following subsections will introduce the operations of the Web Speaking System briefly.

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2.1 The language learning player at the client side

To assist the students in language leaning on listening and speaking, the user interface (UI) of Web Speaking provides the functions of playing the audio files and those of recording the user's voice. Furthermore, the UI displays the wave shapes of the audio files and the user's voice for users to capture the differences and to improve their speaking. For example, once the user selects one topic of the course in upper-left area of the Figure 2, i.e., ``There are always two sides to everything.'' In Figure 2, not only will the content be shown in the upper-right area but also the shape of this audio appears in the middle area. When the users are playing back the audio in the middle area, an indicator will run along the shape of the audio to indicate the exact timing of audio playing.

In addition to listening the audio and watching the shape of it, the users are also able to record their voice into the system, play it out, and compare its shape with the standard one in the course material. In order to prepare the course materials easily and automatically, Web Speaking provides an interface to authorize the use of course materials and to upload and download materials automatically from the course content provider. This is a very convenient feature for the teachers who are not familiar with the operations of the transmitting files in the Web. Furthermore, the teachers could edit the content of the course material and record the audio easily via this interface, such as adding a new topic of the course material or creating a new course in the upper-right area in the Figure 3. They can also playback and record the audio file of the course materials in the bottom area. As such, the language-learning player, including the language learning interface and the course material authoring tools interface, runs at the client side and provides a user interface to access the course materials in the server. In addition, we use the algorithms isolating the utterances of the speech to display the speech waveform in order to facilitate the language learning of students.

Note that the user needs to use the local resources, such as the I/O of the audio interfaces and the I/O of the storage interfaces at the client side. However, this I/O access is not allowable for the browsers, such as the Internet Explorer and the Netscape Navigator. Therefore, we implement a stand-alone language-learning program at the client side by using the Microsoft Visual Basic 6.0 programming tools.

2.2 The course content provider at the server- side

The major tasks of the server are to save and update the teaching materials and to query the databases when so necessary. These tasks are implemented by using the PHP script language and MySQL database at the server side. Since the PHP script language has been integrated with MySQL database, we use it to query the databases (MySQL). The client can then use the HTTP protocol to communicate with the server.

The course content provider is mainly a server combining the Web service and the database manager. It employs the PHP script language to access the MySQL database and to response the client's requests. As mentioned earlier, the server side of Web Speaking saves not only the contents of the courses but also the corresponding audio files in order to support a multimedia-teaching environment. Once the server gets a request, the content provider fetches the requested materials by the user from the database, and then, if the corresponding authentication succeeds, returns the result to the client.

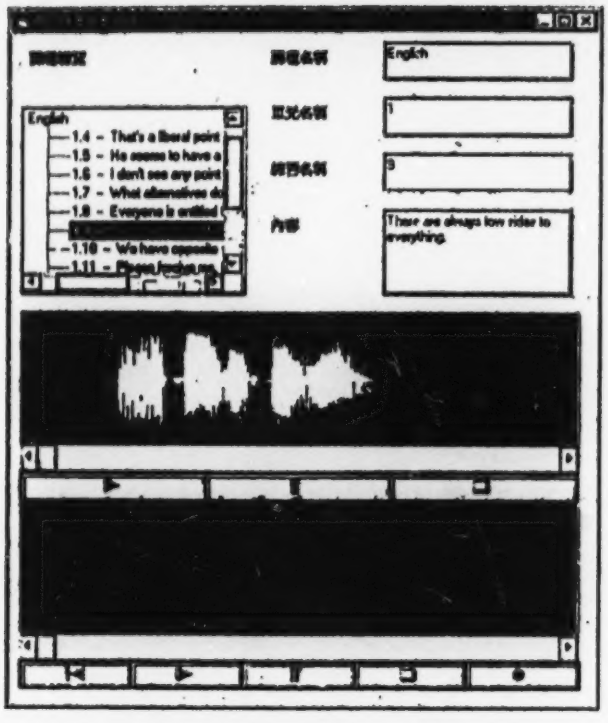
English
1.4 - That's a liberal point
1.5 - He seems to have a
1.6 - I don't see any point
1.7 - What alternatives
1.8 - Everyone is entitled
1.10 - We have opposite
1.11 - Please explain me
English
1
3
There are always low rider to everything.

Figure 2: The language-learning player for the students

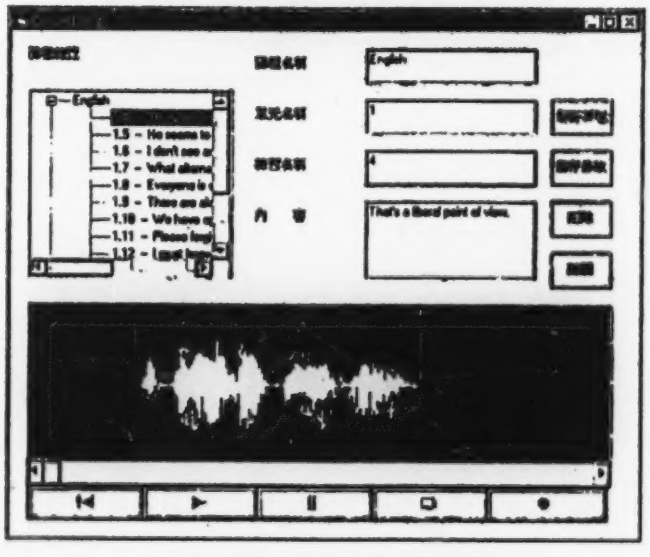

Figure 3: the authoring tools for the teachers

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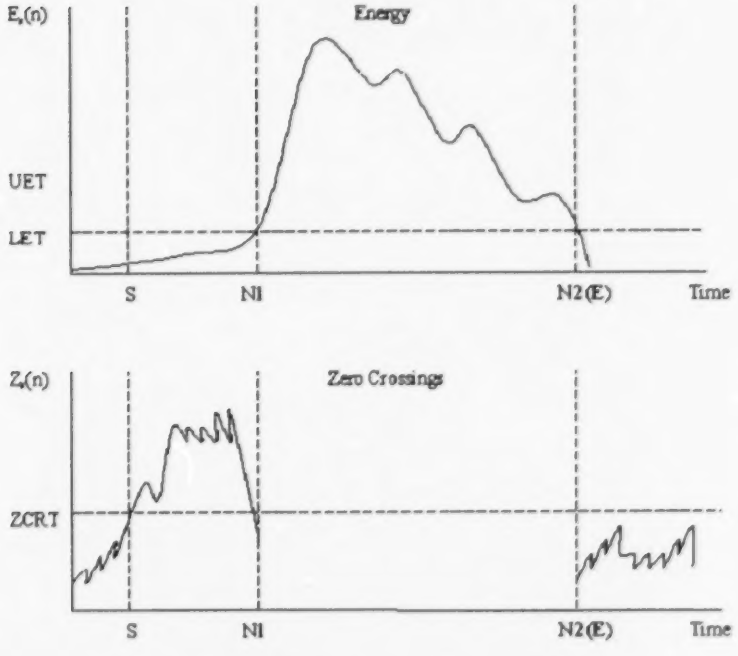
3 End Point Detection for Speech in Web Speaking

We introduce in this section the algorithm used to detect the endpoints of isolated utterances. To help the user learning the language speaking, we display both the waveforms of the speech produced by the user and the standard one prepared by the teacher. In addition, we isolate the utterances of the speech to help the user to understand how the speech looks like. This endpoint detection method [10] uses two parameters, i.e., the short-term energy ($E_s(m)$) and zero crossing rate ($Z_s(m)$), to detect the endpoints of an utterance. These two parameters are calculated as follows, where s(n) means the speech signal, w(n) means the window function, and N means the length of the window.

$$E_s(m) = \sum_{n=m-N+1}^{m} s^2(n)$$

$$Z_s(m) = \frac{1}{N} \sum_{n=m-N+1}^{m} \frac{\left|\operatorname{sgn}\{s(n)\} - \operatorname{sgn}\{s(n-1)\}\right|}{2} w(m-n)$$

$$where \quad \operatorname{sgn}\{s(n)\} = \begin{cases} +1, & s(n) \geq 0 \\ -1 & s(n) < 0 \end{cases}$$



◆ Figure 4: Illustration of the endpoint detection algorithm.

The endpoint detection algorithm is depicted in Figure 4 and described below.

Step 1. Assume that the window function *w(n)* is a rectangular function with the window size *N* being 10 ms, and the first 100 ms of the speech signal is background noise. Then, use this signal segment to calculate the mean and variance of $E_s(m)$ and $Z_s(m)$.

Step 2. Using the statistics derived from Step 1, determine three thresholds, i.e., the upper energy threshold (UET), the lower energy threshold (LET), and the zero crossing rate threshold (ZCRT).

Step 3. Search from the beginning until the energy $E_s(m)$ exceeds the threshold UET. Then, run backward until the energy $E_s(m)$ falls below the threshold LET. We call this point the tentative beginning point N1. The tentative ending point N2 is calculated in a similar way.

Step 4. From the tentative beginning point N1, we examine the zero crossing rate for the previous 250 ms

signal segment. If there are more than three occurrences of counts above the threshold ZCRT, we select the first point backward from N1 whose zero crossing rate is higher than ZCRT as the beginning point (S) of the word. If there are no more than three occurrences of counts above the thres hold ZCRT, the tentative beginning point N1 is directly selected as the beginning point of the word. The ending point (E) is decided in a similar way with exception that the forward searching direction replaces the backward one.

By using the above algorithm we can partition the waveforms of the speech. Furthermore, the language-learning player displays the shapes in the screen and also indicates the timing when the waveform of the speech plays. Thus, this functionality of the language-learning player offers not only the playout of the audio but also the display of the waveform shapes at the same time. This is a very helpful feature for students to learn language speaking.

Note that we can collect students' practicing records in the Web Speaking system. Through some data mining techniques, we can find useful information about the student behaviors, e.g., the common mistakes made by the students. Clearly, using such information discovered, the instructor is able to improve their language teaching by reminding the students of how to speak better when the students encounter common problems.

4 Conclusions

In this paper, we developed a Web Speaking system to improve the language learning and teaching for the students and the teachers. By using Web Speaking, the students are able to not only learn the lessons anywhere at any time but also practice their speaking at leisure pace, thus overcoming the limitation imposed by time and space in traditional teaching environments. The advantage of Web Speaking over some stand-alone commercial language-learning applications lies in the full interactivity Web Speaking provides. The other major contribution is to provide the displays of the speech waveforms produced by the teachers and the students in order to help the students to learn language speaking better. Through the display of the speech waveforms, students can perceive the difference of the speech waveforms between their own speaking and the one prepared by the teacher, and improve their speaking accordingly by themselves.

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Acknowledgement

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WWW-Supported Environments for Learning and Teaching Statistics

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In this paper, we introduce an integrated environment for education of Statistics on WWW. The environment is composed of three Web sites; ITLS (Interactive Text for Learning Statistics on WWW), EBSA (Electronic Book for Statistical Analysis on WWW), and DLLSA (Dynamic Link Library for Statistical Analysis). ITLS is an electronic text of Statistics with graphics, sounds, and interactive software which made by JAVA. EBSA is an electronic library of statistical books which made of the PDF format files. These books are scanned and trans-formed from real books which copyright is expired. DLLSA is a statistical software library of DLL files.

Keywords: **Interactive learning environments, Multimedia and hypermedia in education, Self-driven experiments**

1 Background

Recent rapid coverage of computer networking over wide area of Japan has brought the big change of education environment at universities. In these 1 or 2 years there can be seen lots of universities, especially in non scientific division, have set up the computer networking education system over their several lectures where both teachers and students can access to internet Web sites during the lecture time. It also can be seen at overseas education institutes that there have been increasing of statistical education sites [11][12][13][14] or related reports [1][3][4][6][10].

On the other hand, the society needs the persons with the ability of economical data analysis or econometrical analysis among the general sections especially in finance division. It means graduates from social sciences department with an ability of data analysis will be much more needed who had not so many times got the lecture related to statistical data analysis during university days. Statistics is good discipline for computer networking education because it is important for students to learn not only the theory but also the moving of practical data with changing parameters which will lead them to another side of understanding of real world. It can be expected that interactive education with internet Web will bring the multi-dimensional effects to education world. Those are why we have started jointly developing new styled education system for statistics on Web site. It also could be seen that the government recommend to make more use of networking at education scene in line with the change of world education environment.

2 Purposes and Functions

The purposes of our statistical education system on Web are as follows. i) Joint development of education Web sites with which practical statistics education can be realized, ii) Non scientific students' master of data analysis for actual practice, iii) Teachers can keep their material for education jointly, aiming contents' standardization, iv) Students can learn everywhere they are. We are aiming students can participate to our Web sites and get effective learning chances of statistics and econometrics with interactive ways. It can be expected students would keep highly motivation of learning through active operation of some parameters or data on Web site by themselves. It is clear that this is quite different from traditional education way at the point of students are active in learning without their realizing.

Let me show the concrete functions. i) Retrieval by keyword and its supplementary explanation, ii) Download of lecture slides and practical data, iii) Linkage to reference sites, iv) Offering of database for practice, v) Setting of question and answer section, vi) Online questionnaires system. In addition, Web texts contain some easy comments, colored contents, hyper linked material, images and dynamic graphs to help students who are far from printing types can understand statistical concepts.

Figure 1: Top page of ITLS (http://www.sci.kagoshima-u.ac.jp/~itls/)

3 Contents and Characteristics

We have named our online education system as "ITLS (Interactive Text for Learning Statistics)" which is the abbreviation of interactive text for learning statistics (URL: http://www.sci.kagoshima-u.ac.jp/~itls/). Although students can learn statistics and econometrics along this system's chapter contents, chapters are independent each other, so it doesn't matter going to their objects directly. By trying to interactive learning with this system, students can get statistical, econometrical and other economical index or knowledge depending on their own ability. An interactive and visual learning will much make possible the diversified understanding comparative with the usual learning way only by paper texts.

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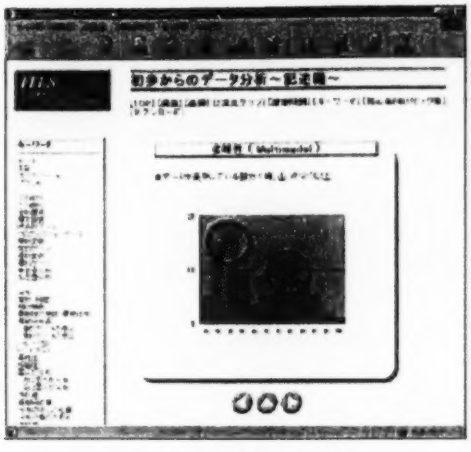

Figure 2: Descriptive statistics

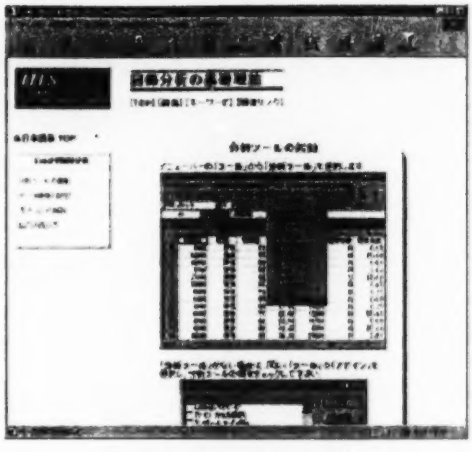

Figure 3: Regression analysis

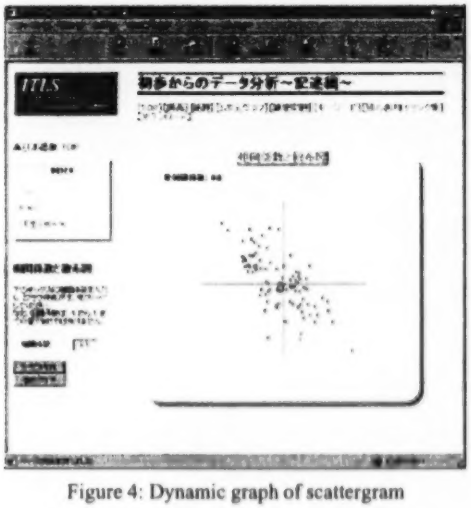

Figure 4: Dynamic graph of scattergram

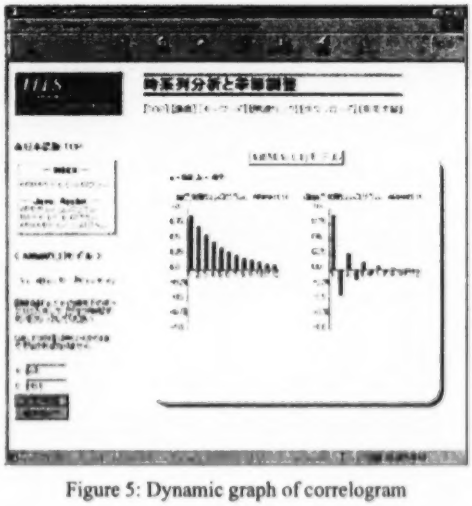

Figure 5: Dynamic graph of correlogram

Figure 2 shows multi-modal distribution in the chapter of descriptive statistics. In this chapter students can get the objective visual panel of contents by retrieving left side keywords list. There are any other explanatory panels of descriptive and inference statistics in this Web system. It is greatly more important for students to see the distribution form visually than to understand statistical concepts only without visualization. Figure 3 shows the regression analysis by familiar tool, for example, Microsoft excel. Each chapter has used the excel or other statistical analysis software as its practical tool, at the same time in the early chapter it has been showed how to use excel as statistical analysis tool mainly. At the demonstrative step of statistics learning, it will be indispensable for students to make use of at least one statistical and analytical software tool which is not common to install in each personal computer at universities except excel.

Figure 4 and 5 show interactive statistical graph. It is not so easy for students who are majo ring not scientific division to understand the relationship between graph and its fixing parameters. These styled system of viewing the dynamic change of various kinds of statistical graph have brought them both visual and intuitive understanding without mathematical formula. This interactive graph making system has been built by JAVA applet or other software tools. There are another contents such as download of lecture slides, making practices into database, setting question and answer section and online questionnaire survey of user along

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whose analytical results we will update our Web contents better in the future. The bulletin of question and answer is very important for all users because it is the best database of several kinds of question and its response from anyone on all sorts of questionnaire of statistical stages. Developing resources and tools also are considered very important module with which the system will be organized better hyper-linked cooperative developing environment.

Figure 6: Top page of EBSA (http://www.sci.kagoshima-u.ac.jp/~ebsa/)

Figure 6 shows our new Web site of "EBSA (Electronic Book for Statistical Analysis)" with which everybody access to this site can do of online reading over old or new valuable books on Web. Now we have provided several important books on this site. These books open to the public under permission of the copyright holder and the publisher. Since these electronic books are scanned and transformed from real books into the PDF format files, we can download and print out all and/or selected contents of the books. Figure 7 shows one of the top page of an electronic book. Each top page contains four parts; the first and the second parts are the links to the contents and the index pages, respectively. The third part is used for keywords search. The fourth part is the print image of the real book. We rewrite these index and contents as text from the image so as to be used by keywords search.

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5 Integration

When we use the statistical analysis software, knowledge of statistics is indispensable for us. It can be seen several reports about the effectiveness of the standing statistical analysis software with statistics education [5][7][8][9]. Working statistics with analytical software will much be an expected style of learning over interactive Web system. Under such background, our project team has already prepared a new library of Dynamic Link Library (DLL) for statistical analysis, which is available as a statistical engine or which can be called from existing general statistical software, for examples SAS, SPSS, S and so on.

The DLLs could be considered as a library for applications on the Windows system as well as that for programming. The DLL contains one or more functions that are compiled, linked and stored separately from the applications using them. One of the advantages of DLLs is that multiple applications can access the same DLL. The DLLs in our library can be accessed from any statistical software or spreadsheet-type software if such software has a facility to call functions or subroutines in DLLs. Source codes for DLLs can be written in several programming languages, for examples, C++, FORTRAN, BASIC, PASCAL and so on.

The contents of multivariate analysis section, for example, are as follows. i) Principal Component Analysis, ii) Metric Multidimensional Scaling, iii) Latent Class Analysis, iv) Hierarchical Cluster Analysis, v) Corresponding Analysis, vi) Discriminate Analysis. All contents of our library can be downloaded and used freely. Details for the library and published DLLs can be obtained from our web site (URL: http://www.sci.kagoshima-u.ac.jp/~dllsa/).

The necessary factors of integrated statistical education system of interactive way on Internet are now on ready among our project team members. To be concrete, it is important and urgent to merge statistical analysis software routines above with online learning system on Web as mentioned before, adding to attach the enrichment of interfaces.

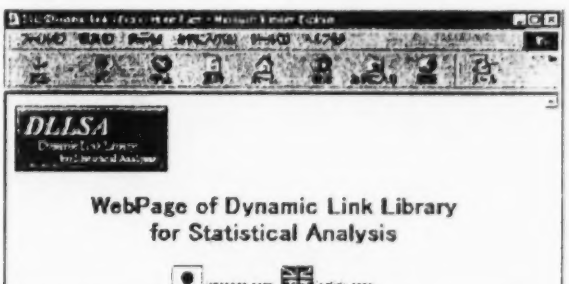

Figure 11: Top page of DLLSA (http://www.sci.kagoshima-u.ac.jp/~dllsa/)

6 Future

Though there are not so many reports about this kind of educational system whole over the world, we can meet some excellent reports about interactive education system on Web [11][12][13][14]. One of our mission is the enrichment of the contents. The join forces of lots of faculties belonging to statistics section will demonstrate the strong power for cooperative Web texts production system. Our next target is achievement of "international cooperative project". We have the plan of translating the part of contents to international version. Now we appreciate the joint research with German colleague who had already established interactive Web site [3][14].

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Finally, we would like to introduce the integrated site of our projects. All contents discussed in this paper can be obtained from this site (URL: http://www.sci.kagoshima-u.ac.jp/~stat/).

Figure 12: Integrated site of our projects (http://www.sci.kagoshima-u.ac.jp/~stat/)

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